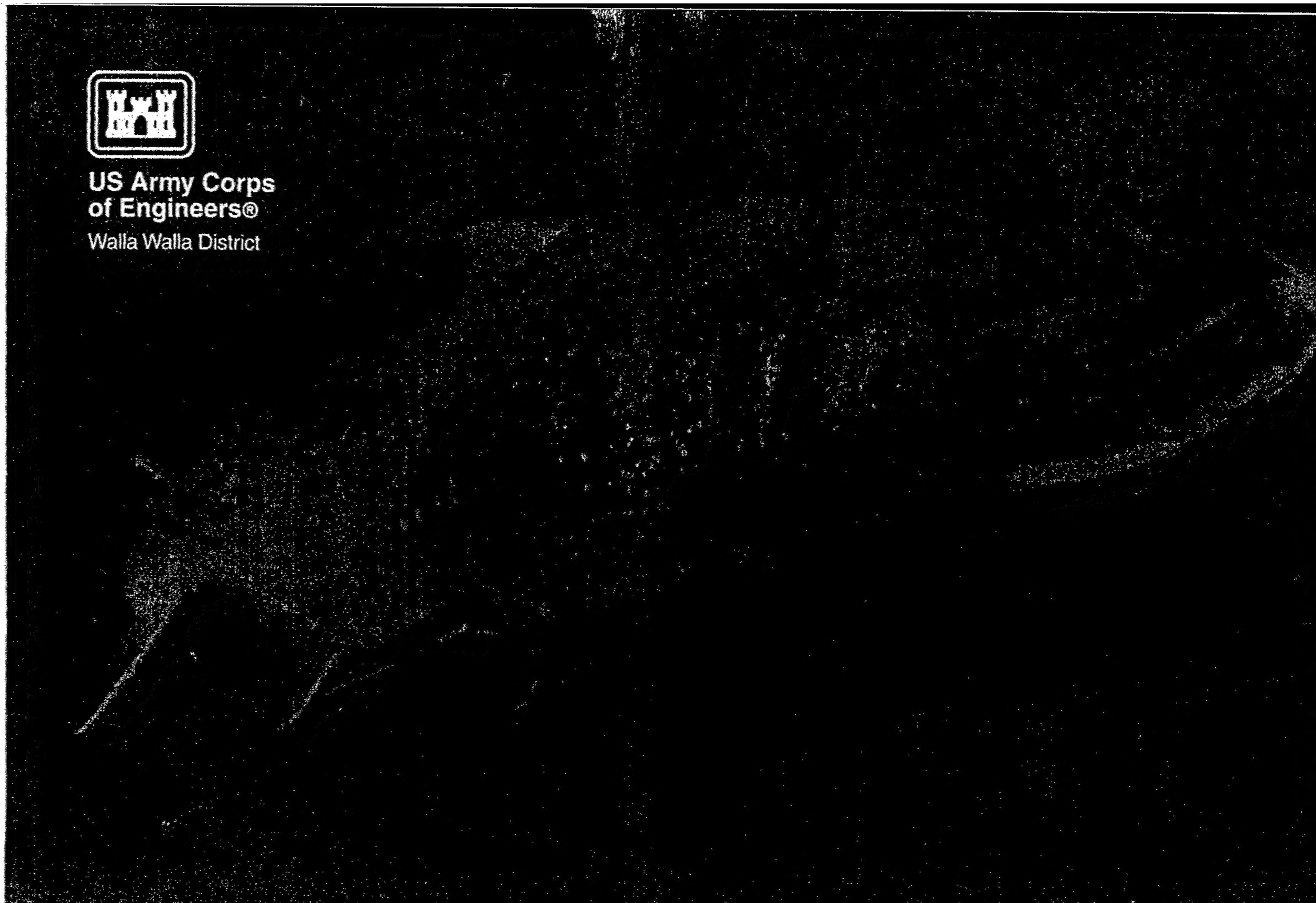

US Army Corps
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Walla Walla District

Lower Snake River Juvenile Salmon Migration Feasibility Report/ Environmental Impact Statement

Appendix J
Plan Formulation

February
2002

REPORT DOCUMENTATION PAGE	*Form Approved OMB No. 0704-0188*

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
February 2002

3. REPORT TYPE AND DATES COVERED
Final

4. TITLE AND SUBTITLE
Lower Snake River Juvenile Salmon Migration Feasibility Report/
Environmental Impact Statement and Appendix J PLAN FORMULATION

5. FUNDING NUMBERS

6. AUTHOR(S)
Corp of Engineers, Walla Walla District

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
US Army Corps of Engineers
Walla Walla District
201 N Third Ave
Walla Walla WA 99362-1876

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
US Army Corps of Engineers
Wash, DC 20314-1000

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
Cooperating Agencies: US Environmental Protection Agency; Bonneville Power Administration; US Bureau of Reclamation

12a. DISTRIBUTION AVAILABILITY STATEMENT
Approval for public release; Distribution is unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*
This Final Feasibility Report/Environmental Impact Statement (RE/EIS) and its 21 appendices document the results of a comprehensive analysis of the four dams on the lower Snake River (collectively called the Lower Snake River Project) and their effects on four lower Snake River salmon and steelhead stocks listed for protection under the Endangered Species Act (ESA). The U.S. Army Corps of Engineers (Corps), along with Bonneville Power Agency (BPA), U. S. Environmental Protection Agency (EPA), and U. S. Bureau of Reclamation (BOR) as cooperating agencies, analyzed four alternatives to evaluate the best way to improve juvenile salmon migration through Lower Snake River Project. The Final FR/EIS includes the best available information on the biological effectiveness, engineering components, costs, economic effects, and other environmental effects associated with the four alternatives: Alternative 1-Existing Conditions, Alternative 2-Maximum Transport of Juvenile Salmon, Alternative 3-Major System Improvements (Adaptive Migration), and Alternative 4-Dam Breaching. In the Final FR/EIS, the Corps identifies Alternative 3-Major System Improvements (Adaptive Migration) as the recommended plan (preferred alternative) and explains the process for selecting that alternative.

14. SUBJECT TERMS
Approval for public release; Distribution is unlimited

15. NUMBER OF PAGES

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20 LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL

FEASIBILITY STUDY DOCUMENTATION

	Document Title
Lower Snake River Juvenile Salmon Migration Feasibility Report/Environmental Impact Statement	
Appendix A (bound with B)	Anadromous Fish Modeling
Appendix B (bound with A)	Resident Fish
Appendix C	Water Quality
Appendix D	Natural River Drawdown Engineering
Appendix E	Existing Systems and Major System Improvements Engineering
Appendix F (bound with G, H)	Hydrology/Hydraulics and Sedimentation
Appendix G (bound with F, H)	Hydroregulations
Appendix H (bound with F, G)	Fluvial Geomorphology
Appendix I	Economics
Appendix J	Plan Formulation
Appendix K	Real Estate
Appendix L (bound with M)	Lower Snake River Mitigation History and Status
Appendix M (bound with L)	Fish and Wildlife Coordination Act Report
Appendix N (bound with O, P)	Cultural Resources
Appendix O (bound with N, P)	Public Outreach Program
Appendix P (bound with N, O)	Air Quality
Appendix Q (bound with R, T)	Tribal Consultation and Coordination
Appendix R (bound with Q, T)	Historical Perspectives
Appendix S*	Snake River Maps
Appendix T (bound with R, Q)	Clean Water Act, Section 404(b)(1) Evaluation
Appendix U	Response to Public Comments

*Appendix S, Lower Snake River Maps, is bound separately (out of order) to accommodate a special 11 x 17 format.

The documents listed above, as well as supporting technical reports and other study information, are available on our website at http://www.nww.usace.army.mil/lsr. Copies of these documents are also available for public review at various city, county, and regional libraries.

AQM03-06-1245

STUDY OVERVIEW

Purpose and Need

Between 1991 and 1997, due to declines in abundance, the National Marine Fisheries Service (NMFS) made the following listings of Snake River salmon or steelhead under the Endangered Species Act (ESA) as amended:

- sockeye salmon (listed as endangered in 1991)
- spring/summer chinook salmon (listed as threatened in 1992)
- fall chinook salmon (listed as threatened in 1992)
- steelhead (listed as threatened in 1997).

In 1995, NMFS issued a Biological Opinion on operations of the Federal Columbia River Power System (FCRPS). Additional opinions were issued in 1998 and 2000. The Biological Opinions established measures to halt and reverse the declines of ESA-listed species. This created the need to evaluate the feasibility, design, and engineering work for these measures.

The Corps implemented a study (after NMFS' Biological Opinion in 1995) of alternatives associated with lower Snake River dams and reservoirs. This study was named the Lower Snake River Juvenile Salmon Migration Feasibility Study (Feasibility Study). The specific purpose and need of the Feasibility Study is to evaluate and screen structural alternatives that may increase survival of juvenile anadromous fish through the Lower Snake River Project (which includes the four lowermost dams operated by the Corps on the Snake River—Ice Harbor, Lower Monumental, Little Goose, and Lower Granite Dams) and assist in their recovery.

Development of Alternatives

The Corps' response to the 1995 Biological Opinion and, ultimately, this Feasibility Study, evolved from a System Configuration Study (SCS) initiated in 1991. The SCS was undertaken to evaluate the technical, environmental, and economic effects of potential modifications to the configuration of Federal dams and reservoirs on the Snake and Columbia Rivers to improve survival rates for anadromous salmonids.

The SCS was conducted in two phases. Phase I was completed in June 1995. This phase was a reconnaissance-level assessment of multiple concepts, including drawdown, upstream collection, additional reservoir storage, migratory canal, and other alternatives for improving conditions for anadromous salmonid migration.

The Corps completed a Phase II interim report on the Feasibility Study in December 1996. The report evaluated the feasibility of drawdown to natural river levels, spillway crest, and other improvements to existing fish passage facilities.

Based in part on a screening of actions conducted for the Phase I report and the Phase II interim report, the study now focuses on four courses of action:

- Existing Conditions
- Maximum Transport of Juvenile Salmon

- Major System Improvements
- Dam Breaching.

The results of these evaluations are presented in the combined Feasibility Report (FR) and Environmental Impact Statement (EIS). The FR/EIS provides the support for recommendations that will be made regarding decisions on future actions on the Lower Snake River Project for passage of juvenile salmonids. This appendix is a part of the FR/EIS.

Geographic Scope

The geographic area covered by the FR/EIS generally encompasses the 140-mile long lower Snake River reach between Lewiston, Idaho and the Tri-Cities in Washington. The study area does slightly vary by resource area in the FR/EIS because the affected resources have widely varying spatial characteristics throughout the lower Snake River system. For example, socioeconomic effects of a permanent drawdown could be felt throughout the whole Columbia River Basin region with the most effects taking place in the counties of southwest Washington. In contrast, effects on vegetation along the reservoirs would be confined to much smaller areas.

Identification of Alternatives

Since 1995, numerous alternatives have been identified and evaluated. Over time, the alternatives have been assigned numbers and letters that serve as unique identifiers. However, different study groups have sometimes used slightly different numbering or lettering schemes and this has led to some confusion when viewing all the work products prepared during this long period. The primary alternatives that are carried forward in the FR/EIS currently involve the following four major courses of action:

Alternative Name	PATH[1/] Number	Corps Number	FR/EIS Number
Existing Conditions	A-1	A-1	1
Maximum Transport of Juvenile Salmon	A-2	A-2a	2
Major System Improvements	A-2'	A-2d	3
Dam Breaching	A-3	A-3a	4

[1/] Plan for Analyzing and Testing Hypotheses

Summary of Alternatives

The **Existing Conditions Alternative** consists of continuing the fish passage facilities and project operations that were in place or under development at the time this Feasibility Study was initiated. The existing programs and plans underway would continue unless modified through future actions. Project operations include fish hatcheries and Habitat Management Units (HMUs) under the Lower Snake River Fish and Wildlife Compensation Plan (Comp Plan), recreation facilities, power

generation, navigation, and irrigation. Adult and juvenile fish passage facilities would continue to operate.

The **Maximum Transport of Juvenile Salmon Alternative** would include all of the existing or planned structural and operational configurations from the Existing Conditions Alternative. However, this alternative assumes that the juvenile fishway systems would be operated to maximize fish transport from Lower Granite, Little Goose, and Lower Monumental and that voluntary spill would not be used to bypass fish through the spillways (except at Ice Harbor). To accommodate this maximization of transport, some measures would be taken to upgrade and improve fish handling facilities.

The **Major System Improvements Alternative** would provide additional improvements to what is considered under the Existing Conditions Alternative. These improvements would be focused on using surface bypass facilities such as surface bypass collectors (SBCs) and removable spillway weirs (RSWs) in conjunction with extended submerged bar screens (ESBSs) and a behavioral guidance structure (BGS). The intent of these facilities would be to provide more effective diversion of juvenile fish away from the turbines. Under this alternative, an adaptive migration strategy would allow flexibility for either in-river migration or collection and transport of juvenile fish downstream in barges and trucks.

The **Dam Breaching Alternative** has been referred to as the "Drawdown Alternative" in many of the study groups since late 1996 and the resulting FR/EIS reports. These two terms essentially refer to the same set of actions. Because the term drawdown can refer to many types of drawdown, the term dam breaching was created to describe the action behind the alternative. The Dam Breaching Alternative would involve significant structural modifications at the four lower Snake River dams, allowing the reservoirs to be drained and resulting in a free-flowing yet controlled river. Dam breaching would involve removing the earthen embankment sections of the four dams and then developing a channel around the powerhouses, spillways, and navigation locks. With dam breaching, the navigation locks would no longer be operational, and navigation for large commercial vessels would be eliminated. Some recreation facilities would close while others would be modified and new facilities could be built in the future. The operation and maintenance of fish hatcheries and HMUs would also change, although the extent of change would probably be small and is not known at this time.

Authority

The four Corps dams of the lower Snake River were constructed and are operated and maintained under laws that may be grouped into three categories: 1) laws initially authorizing construction of the project, 2) laws specific to the project passed subsequent to construction, and 3) laws that generally apply to all Corps reservoirs.

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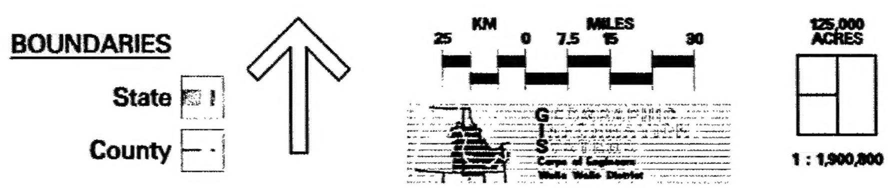

LOWER SNAKE RIVER
Juvenile Salmon Migration Feasibility Study

REGIONAL BASE MAP

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Final

Lower Snake River Juvenile Salmon Migration Feasibility Report/ Environmental Impact Statement

Appendix J

Plan Formulation

Produced by

U.S. Army Corps of Engineers

Walla Walla District

February 2002

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FOREWORD

Appendix J was prepared by the U.S. Army Corps of Engineers (Corps), Walla Walla District. This appendix is one part of the overall effort of the Corps to prepare the Lower Snake River Juvenile Salmon Migration Feasibility Report/Environmental Impact Statement (FR/EIS).

The Corps has reached out to regional stakeholders (Federal agencies, tribes, states, local governmental entities, organizations, and individuals) during the development of the FR/EIS and appendices. This effort resulted in many of these regional stakeholders providing input and comments, and even drafting work products or portions of these documents. This regional input provided the Corps with an insight and perspective not found in previous processes. A great deal of this information was subsequently included in the FR/EIS and appendices; therefore, not all of the opinions and/or findings herein may reflect the official policy or position of the Corps.

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TABLES

ACRONYMS AND ABBREVIATIONS

AAQS	ambient air quality standards
AFEP	Anadromous Fish Evaluation Program
AP&D	Advanced Planning & Design
ARO	auxiliary regulation outlet
BGS	behavioral guidance structure
BOR	U.S. Bureau of Reclamation
BPA	Bonneville Power Administration
cfs	cubic feet per second
CO	carbon monoxide
CO_2	carbon dioxide
Corps	U.S. Army Corps of Engineers
CRFMP	Columbia River Fish Mitigation Program
CRiSP	Columbia River Salmon Passage Model
CRSMA	Columbia River Salmon Mitigation Analysis
DMS	downstream migrant system
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
ESA	Endangered Species Act
ESBS	extended submerged bar screen
FGE	fish guidance efficiency
FLUSH	Fish Leaving Under Several Hypotheses
FPDEP	Fish Passage Development and Evaluation Program
GHG	greenhouse gas
HEP	Habitat Evaluation Procedure
HYSSR	Hydro System Seasonal Regulation Program
INEEL	Idaho National Engineering and Environmental Laboratory
ISAB	Independent Scientific Advisory Board
JBS	juvenile bypass system
KAF	thousand acre-feet
LCR	Lower Columbia River
LGR	Lower Granite Dam
LSR	lower Snake River
LSRFWCP	Lower Snake River Fish and Wildlife Compensation Plan
LSRP	Lower Snake River Project
MAF	million acre-feet
MCY	million cubic yards
MOP	minimum operating pool
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NO_2	nitrogen dioxide
NO_x	nitrogen oxide

NPPC	Northwest Power Planning Council
O&M	operation and maintenance
PATH	Plan for Analyzing and Testing Hypotheses
PIES	Project Improvements for Endangered Species
PM_{10}	Particulate matter with aerodynamic diameters less than 10 micrometers
PUD	Public Utility District
RSW	removable spillway weir
SBC	surface bypass collector
SCS	System Configuration Study
SCT	System Configuration Team
SLCM	Stochastic Lifecycle Model
SO_2	sulfur dioxide
SOR	Columbia River System Operation Review
S/S	spring/summer
STS	submerged traveling screen
TAG	Technical Advisory Group
TAP	toxic air pollutant
TDG	total dissolved gas
TPY	tons per year
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
VOC	volatile organic compound
WDFW	Washington Department of Fish and Wildlife

ENGLISH TO METRIC CONVERSION FACTORS

To Convert From	To	Multiply By
LENGTH CONVERSIONS:		
Inches	Millimeters	25.4
Feet	Meters	0.3048
Miles	Kilometers	1.6093
AREA CONVERSIONS:		
Acres	Hectares	0.4047
Acres	Square meters	4047
Square Miles	Square kilometers	2.590
VOLUME CONVERSIONS:		
Gallons	Cubic meters	0.003785
Cubic yards	Cubic meters	0.7646
Acre-feet	Hectare-meters	0.1234
Acre-feet	Cubic meters	1234
OTHER CONVERSIONS:		
Feet/mile	Meters/kilometer	0.1894
Tons	Kilograms	907.2
Tons/square mile	Kilograms/square kilometer	350.2703
Cubic feet/second	Cubic meters/sec	0.02832
Degrees Fahrenheit	Degrees Celsius	(Deg F –32) x (5/9)

1. Introduction

The intent of this appendix is to explain how the U.S. Army Corps of Engineers (Corps) plan formulation process evolved over time and the actions and decisions that influenced the outcome of the alternatives being studied in the Lower Snake River Juvenile Salmon Migration Feasibility Study (Feasibility Study). This appendix identifies the alternatives studied in detail and the trade-offs by alternative. Regionally coordinated efforts have been made to involve the public, stakeholders, local governments, states, tribes, and Federal agencies in the identification, evaluation, and recommendation of the alternatives considered.

The Corps' plan formulation process originated with the System Configuration Study (SCS). This study was initiated to evaluate the technical, environmental, and economic effects of potential modifications to the configuration of Federal dams and reservoirs on the lower Snake and Columbia rivers. The purpose of these structural modifications was to improve migration conditions and hydropower system survival rate for anadromous salmonids. The SCS evolved in response to the Northwest Power Planning Council's (NPPC) Fish and Wildlife Program Amendments (NPPC, 1991), issued in December 1991. The SCS assessed various possible alternatives for improving conditions for anadromous salmonid migration.

The SCS was presented in two phases. Phase I, which was completed in June 1995, was a reconnaissance level assessment of multiple concepts including drawdown, upstream collection, additional reservoir storage, a migratory canal, and several other alternatives. Many of these concepts were identified in the NPPC Strategy for Salmon (NPPC, 1992) and the National Marine Fisheries Service's (NMFS) Reinitiation of Consultation on 1995-1998 Operation of the Federal Columbia River Power System and Juvenile Transportation in 1995 and Future Years (NMFS 1995 Biological Opinion), dated March 2, 1995. The alternatives that displayed the most potential for benefiting anadromous fish were carried into Phase II where detailed studies were conducted and a recommended plan (preferred alternative) was identified.

Several studies were initiated as part of the SCS Phase II. One of these studies became known as the Lower Snake River Juvenile Salmon Migration Feasibility Study. The purpose of this Feasibility Study was to evaluate alternatives associated with improved juvenile salmon passage through the Lower Snake River Project. It is important to note that recommended studies associated with the lower Columbia River projects were not carried forward into the Feasibility Study. It was intended that other studies or actions would address the lower Columbia River dams and reservoirs. The Feasibility Study was conducted in two steps. The two steps correlated to the two major decision points identified by the NMFS 1995 Biological Opinion.

The first step was to develop the Interim Status Report (Corps, 1996). The primary purpose of this report was to prescreen alternatives in order to make a decision regarding the selection of one of the three drawdown alternatives for the lower Snake River. This step was needed in order to either proceed with detailed engineering, or proceed with the elimination of any further consideration of drawdown.

The findings of the Interim Status Report indicated there was insufficient information to make a recommendation on the best configuration of the hydropower system to safely pass juvenile salmon in the lower Snake River. The conclusion resulted in the Corps moving to the second step. The second step involved the preparation of a Feasibility Study, which would allow for further consideration of three pathways to improve salmon passage.

2. Background

2.1 Authority

The SCS Phase I and the Feasibility Study are elements of the Columbia River System Mitigation Analysis (CRSMA), which is a sub-program to the Columbia River Fish Mitigation Program (CRFMP), previously known as the Columbia River Juvenile Fish Mitigation Program. These studies, as components of the CRSMA, were conducted under the existing authorities for the eight dams and reservoirs on the lower Columbia and lower Snake Rivers. For Bonneville Dam and reservoir, the primary authority is the Rivers and Harbors Act of 1935, Public Law 74-409, dated August 30, 1935. For the John Day and The Dalles Dams and reservoirs, the primary authority is the Rivers and Harbors Act of 1950, Public Law 81-516, dated May 17, 1950. For the Lower Snake River dams and reservoirs, the primary authority is the Rivers and Harbors Act of 1945, Public Law 79-14, dated March 2, 1945.

2.2 The Corps' Involvement in Salmon Recovery

There are many factors affecting the decline of the anadromous fishery within the Columbia River Basin. These factors include:

- overharvesting
- loss of habitat
- hatchery operation
- migration-related problems associated with dams and reservoirs and other human-related problems (water quality, irrigation, urbanization, etc.).

The CRFMP provides mitigation for the impact of Corps dams on migrating juvenile salmon and steelhead. This program includes construction of new or improved facilities for protecting and bypassing juvenile fish at the eight mainstem dams. Additional mitigation measures are being considered as a result of NPPC's regional efforts for rebuilding upriver salmon stocks and NMFS listing of Snake River salmon as threatened or endangered. The CRSMA began in 1991, and has provided a regionally coordinated scope for Corps actions in the furtherance of both regional and NMFS recovery plans.

The Corps has four primary functions in assisting regional efforts to rebuild Columbia River salmon populations:

- providing river operations at the dams and reservoirs to minimize adverse effects on adult and juvenile fish passage through the system
- operating the juvenile fish transportation program
- constructing and operating improved facilities for juvenile and adult passage at Columbia and Snake River Dams (e.g., powerhouse fish screens and juvenile bypasses)
- providing the region with technical and engineering information relating to hydrosystem operational and structural options.

The CRSMA and SCS are efforts to provide the best available scientific and technical information on regionally proposed measures for hydrosystem passage improvements. The Corps' Anadromous Fish Evaluation Program (AFEP), formerly known as the Fish Passage Development and Evaluation Program (FPDEP), is another area where the Corps is providing engineering and technical assistance to the regional effort.

2.3 Other Related Studies and Processes

This section contains brief descriptions of related programs and studies that focus specifically on the coordinated Columbia River System.

2.3.1 Columbia River System Operation Review

The Columbia River System Operation Review (SOR) was a study undertaken jointly by the Corps, Bonneville Power Administration (BPA), and the U.S. Bureau of Reclamation (BOR). The SOR is a comprehensive study intended to coordinate the long-term operation of Federal water resource projects in the Columbia River Basin. Within the Corps, the North Pacific Division led project management with technical assignments designated to the Walla Walla, Portland, and Seattle Districts. Cooperating agencies included NMFS, the United States Fish and Wildlife Service (USFWS), the National Park Service, and the United States Forest Service (USFS). One of the key goals of the SOR was to establish guidelines for the agencies to follow in operating the coordinated Columbia River System. The SOR took into account impacts on all river uses, including anadromous fish, power, recreation, resident fish, irrigation, cultural, and navigation. It also provided National Environmental Policy Act (NEPA) documentation to review the Pacific Northwest Coordination Agreement and the Canadian Entitlement Allocation Agreements. The Pacific Northwest Coordination Agreement is a contract that sets the terms for coordinated operation of the river system for power production. The Canadian Entitlement Allocation Agreements provide the United States the utilities to deliver a certain amount of energy to Canada as a result of the Columbia River Treaty.

The SCS is related to the SOR, but is a separate study. The SCS evaluated physical or configuration modifications to the Federal hydropower system, while the SOR investigated potential operational changes to the same system. Some of the operational changes investigated under the SOR would required physical modifications of existing facilities (dams and/or new construction). These changes are addressed in the SCS. Therefore, SCSs have been coordinated with the SOR.

The SOR released a Final Environmental Impact Statement (EIS) in November 1995 (BPA et al., 1995). Preliminary operational and impact analyses of the lower Snake River and the John Day reservoir drawdown alternatives conducted in the SOR provide some of the analysis reflected in the SCS. Hydroregulation studies, environmental impacts, and economic effects are areas of united analysis between the SOR and the SCS. Drawdown effects on anadromous fish survival are a key area of common analysis. Some of the anadromous fish evaluations continued in the SOR included the analysis of the effects of the juvenile fish transportation program and its relationship to river operation alternatives to improve juvenile survival.

2.3.2 The NPPC Fish and Wildlife Program

The NPPC, made up of representatives from Idaho, Montana, Oregon, and Washington, are entrusted (under the Pacific Northwest Electric Power Planning and Conservation Act of 1980) to perform the following tasks:

- develop a conservation and electric power plan that will ensure an adequate, efficient, economical, and reliable power supply for the Pacific Northwest
- prepare a program to protect, mitigate, and enhance fish and wildlife (including related spawning grounds and habitat) that are affected by the development and operation of hydroelectric projects on the Columbia River and its tributaries
- involve the public in these activities.

In 1982, NPPC issued a comprehensive Columbia River Basin Fish and Wildlife Program (NPPC, 1982) addressing salmon and steelhead production; safe passage; harvest management; resident fish and wildlife protection; future hydroelectric development; and coordination among Federal agencies with responsibility for Columbia River Basin resources. It has since been amended several times. The first three phases of that series of amendments are known as the Strategy for Salmon. These phases addressed production and habitat measures for salmon and steelhead stocks, mainstem survival, harvest, rebuilding schedules, and biological objectives. The fourth phase addressed protection of resident fish and wildlife.

Many of the measures in the Strategy for Salmon recommendations have been incorporated into the annual operating plans, as well as in the SCS and the SOR evaluations.

In 2000, NPPC issued the fifth revision of the Columbia River Basin Fish and Wildlife Program (NPPC, 2000). The program's goals, objectives, scientific foundation, and actions are structured in a framework that is intended to bring together, as closely as possible, Endangered Species Act requirements, the broader requirements of the Pacific Northwest Electric Power Planning and Conservation Act, and the policies of the states and Indian tribes of the Columbia River Basin.

2.3.3 Endangered Species Act Recovery Plan

While programs to improve the status of Snake River salmon have been ongoing for decades, the filing of formal petitions with NMFS in 1990 for Endangered Species Act (ESA) listing of three stocks as threatened or endangered focused regional attention on the need for more aggressive action addressing the precarious status of specific wild salmon stocks. Outgrowths of the petition filing included the Salmon Summit, the beginning of NPPC's amendments to rebuild salmon stocks, and several Corps studies to improve dam operations. The formal listings of Snake River sockeye in December 1991 as endangered, and Snake River spring/summer and fall chinook in April 1992 as threatened, triggered the initiation of the NMFS recovery plan and Federal agency consultation on the effects of actions, including the operation of the coordinated Columbia River System on listed salmon. Under the ESA, the Corps and cooperating agencies have a responsibility to ensure that their actions do not jeopardize the continued existence of the listed species. Since then, critical habitat was designated for Snake River sockeye, spring/summer chinook, and fall chinook in December 1993. The Snake River wild steelhead were listed as threatened in August 1997.

Ultimately, a recovery plan will guide all activities that might affect salmon restoration and recovery. A recovery team has been established and draft recovery plan recommendations have been developed. These recommendations will assist NMFS in preparing a recovery plan. The recovery plan will provide guidance on policies and actions for restoring listed Snake River salmon stocks. In addition, a group known as the Federal Caucus, which includes NMFS, Corps, BOR, BPA, U.S. Environmental Protection Agency (EPA), Bureau of Indian Affairs, Bureau of Land Management, USFWS, and USFS, have come together to develop a multi-species recovery plan that defines Federal obligations consistent with ESA as well as non-Federal (e.g., state, local, and private) activities necessary for recovery of ESA-listed species in the Columbia River Basin. The multi-species recovery plan is focused on hydro, habitat, harvest, and hatcheries actions.

2.3.4 The Bureau of Reclamation Snake River Basin Storage Appraisal Study

In response to the Salmon Summit and NPPC's amendment for its Fish and Wildlife Program, BOR facilitated an interagency inventory and analysis of additional potential storage sites in the Snake River Basin. These additional storage sites were evaluated for use to augment or improve flows for anadromous fish, or to refill the Lower Snake River Project following drawdown, particularly during their downstream migration period. The study participants include representatives from BOR, the Corps, BPA, and the various involved states. The final report, Snake River Basin Storage Appraisal Study (BOR et al., 1994), from BOR was submitted to NPPC in February 1994.

2.3.5 John Day Drawdown Phase I Study

The Corps initiated a study to access the social, economic, and biological impacts of drawing down the John Day Reservoir. A set of regional goals for drawdown of the John Day reservoir were identified in the NMFS's draft Recovery Plan for Snake River salmon, the Tribal Restoration Plan, and the NPPC's Fish and Wildlife Program which helped guide the Phase I Study.

The goals for the John Day Phase I Study included:

- Evaluate the potential of a John Day reservoir drawdown to protect, mitigate, and enhance fish (particularly anadromous fish) and wildlife populations and habitat of the Columbia River and its tributaries, and evaluate how drawdown might contribute to an increase in the number of harvestable anadromous fish.
- Evaluate the social, economic, and biological benefits and costs of a drawdown of the John Day reservoir water surface elevation 265 to spillway crest elevation 215 or natural river evaluation 165.
- Make information available that may be useful to the Lower Snake River Juvenile Salmon Migration Feasibility Study.
- Develop information that may be used to determine whether it is appropriate to continue further studies to drawdown the John Day reservoir.

After assessing the potential biological benefits and economic costs, the recommendation was that no further study is required for Congress and the Region to decide on drawdown of the John Day reservoir, or removal of John Day Dam. The John Day Phase I study indicated that drawdown of the John Day reservoir contributes little to the probability of survival and recovery of listed Snake River salmon stocks (Corps, 2000).

3. SCS Phase I - Description of Alternatives

The objective of the SCS as previously stated was to define and evaluate alternatives for improving mainstem passage of juvenile and adult anadromous fish. Under this major objective, alternatives addressed one or both of two general sub-objectives: 1) reduce reservoir-associated mortality; and 2) reduce dam-passage mortality. Reservoir-associated mortality factors include predation and effects associated with fish travel time to the estuary (i.e., incidence of disease and physiological conditioning for transition from freshwater to saltwater environment). These and other concerns are thought to be fundamental to, or inherent in the relationships between, flow, velocity, fish travel time, and juvenile survival generally supported in the region, but not well understood. Mainstem reservoir drawdowns, flow augmentation, and improvements in juvenile fish collection and transportation are the concepts considered to address this objective (Table 3-1). Dam-related mortality includes turbine, juvenile bypass system and spillway passage-induced mortality on juvenile fish, and adult passage mortality. Various system improvements, collection and transportation options, and mainstem drawdowns were considered to reduce or eliminate dam-related mortality.

Table 3-1. General Objectives of the SCS Phase I Studies

Alternative	Reduce Reservoir-Associated Mortality	Reduce Dam Passage-Associated Mortality
Lower Snake River Project Drawdown	✓	✓
John Day Drawdown	✓	
Additional Upstream Storage	✓	
Upstream Collection and Conveyance	✓	✓
System Improvements		✓

Many of the structural and operational alternatives and/or concepts considered in Phase I were initially identified in the 1990 and 1991 Salmon Summit, and carried forward in NPPC's Strategy for Salmon. The alternative long-term actions considered in Phase I include:

- annual drawdown of the four lower Snake River reservoirs
- drawdown of John Day reservoir on the lower Columbia River
- development of additional storage in the upper Snake River Basin to support flow augmentation
- constructing an upstream (above Lower Granite Dam) collector facility and a new conveyance system, such as a migratory canal or pipeline, past the mainstem dams
- making further improvements to existing systems to aid salmon migration.

These alternatives are described in detail in the following paragraphs. For more discussion on the modifications, schedules, and costs associated with the SCS Phase I proposals, refer to the SCS Phase I report (Corps, 1994).

3.1 Lower Snake River Drawdown

3.1.1 General

The idea of drawing down reservoirs below design operational levels during the salmon migration season first surfaced at the regional Salmon Summit meetings, convened by Senator Mark Hatfield in 1990. The idea was pursued in the NPPC's Fish and Wildlife Program Amendments.

There are four dams and reservoirs located on the Snake River between river miles (RMs) 9.7 and 107.5. The Lower Snake River Project includes Ice Harbor (RM 9.7), Lower Monumental (RM 41.6), Little Goose (RM 70.3), and Lower Granite (RM 107.5). The Lower Snake River Project was constructed between 1961 and 1975, and is operated as run-of-river for multiple uses. The maximum lift for the navigation locks and head for power generation varies from 101 to 105 feet at each facility.

The Corps conducted a drawdown test of the Lower Granite and Little Goose reservoirs on the lower Snake River in March 1992 to measure the physical impacts of drawdown. The test was purposely conducted when there were few salmon in the river, out of concern that a test with migrating fish in the system would have harmful impacts on already troubled salmon stocks.

3.1.2 Objective

Various proposals have suggested changing the current operation of the Lower Snake River Project. These operational changes focused on decreasing the average water travel time through the reservoirs created by the four lower Snake River dams. Water travel time has been identified as a possible factor in juvenile fish survival. The relationship between water travel time, migration time, and fish survival is a general one, and is not considered to be a quantitative expression. Migration research that supports this general relationship applies mainly to spring and summer chinook salmon. One method suggested for achieving a decreased water travel time involves reducing the reservoir cross-sectional area by operating the reservoirs at lower water surface elevations. The proposed operation would occur during the annual juvenile migration period. Drawdown is considered to be an effort to keep juvenile fish migrating in-river, thus replacing the need for the existing transportation program. In any event, navigation would not be possible with lowered reservoir water surface elevations on the Snake River. Collection and transport from McNary Dam would be possible; however, this was not evaluated because it was not consistent with the goal of in-river navigation.

3.1.3 Operational Drawdown Alternatives

This paragraph describes the operational drawdown alternatives under consideration for the Lower Snake River Project. There are three basic types of drawdown options that were used to develop the array of alternatives:

- Variable Pool–This would allow the reservoir surface elevation to be lowered or raised (depending on river flow or discharge) to meet flow velocity objectives.
- Constant Pool–The reservoir, under drawdown conditions, would be operated within a 5-foot operating range, similar to the existing operating condition.

- Natural River Flow–To the extent possible, reservoirs would be lowered to allow the river to flow freely past the dams at the level of the natural river.

Several different drawdown levels could be examined. These levels range from normal minimum operating pool (MOP) levels to a complete river bypass of the dams (near pre-dam river conditions), with numerous drawdown levels that fall between these two extremes. There are various ways each dam's operation could be modified in order to achieve a particular drawdown pool level. Under certain proposed drawdown levels, the drawdown condition can be achieved by passing water through the powerhouse, over the spillway, or both, depending on river discharge. Two different modes of operation could also occur once the drawdown level is substantially achieved. The pool level behind each dam could be maintained at near constant levels (±5 feet), or could be allowed to fluctuate as river flows fluctuate.

Twenty-two different alternatives were identified as potential drawdown conditions on the lower Snake River. The alternatives were defined by the drawdown level, as well as by the features at each dam that would need to be modified or newly constructed to achieve the drawdown level.

3.1.4 Initial Alternative Screening

To narrow the number of drawdown alternatives for which design and cost information would be required, conceptual designs were screened based on engineering feasibility, biological effectiveness, and acceptability. The Technical Advisory Group (TAG), established by the Corps and consisting of Federal and state agency biologists, accomplished the review of biological effectiveness. Alternatives that proposed spillway-only operations were found to be not feasible due to the adverse impact on adult fish passage, associated high dissolved gas levels, and problems associated with passing juvenile fish over the spillways. Variable pool alternatives that require turbine operation below existing spillway crest elevations were also eliminated due to unacceptable impacts to turbines and unacceptable operational impacts to fish bypass system components.

During initial screening, 12 alternatives were found to be unacceptable and were eliminated from further study based on the reasons identified in the previous paragraph. Ten alternatives were evaluated further. These 10 alternatives are outlined in the following section. Table 3-2 shows a list of all 22 alternatives initially considered and identifies those considered further.

3.1.5 Alternatives Considered Further

The 10 alternatives that were not eliminated during the initial screening process are shown in Table 3-2. The reservoir pools would be operated at a drawdown level during the juvenile fish outmigration from 15 April through 15 June or from 15 April through Labor Day. Pools would be returned to normal operating levels for the rest of the year. The tense in which these alternatives are presented is as they were prepared for the SCS Phase I report.

3.1.5.1 Alternative 4A—Natural River Option

This concept would produce the most extreme drawdown operation of any of the alternatives considered in SCS Phase I. For river flows of 20,000 cubic feet per second (cfs), the total drawdown below normal maximum pool levels would be approximately 115 feet at Lower Granite Dam, 114 feet at Little Goose Dam, 108 feet at Lower Monumental Dam, and 97 feet at Ice Harbor

Table 3-2. Initial Screening

Number	Description	Drawdown Level (feet)	Recommendation for Further Study
	Variable Pool – No Powerhouse Operation[1/]		
1	Existing Spillway Only	28 to 57	Eliminated
2	Modified Spillway Only	38 to 67	Eliminated
3	New Low-level Spillway Only	52 to 76	Eliminated
4	Auxiliary Regulation Outlet (ARO) Only	>76	Eliminated
4A	Natural River Option	Near Freeflow	Added
	Variable Pool with Existing Powerhouse		
5	Existing Powerhouse with Existing Spillway	28 to 57	yes
6	Existing Powerhouse with Modified Existing Spillway	38 to 67	Eliminated
7	Existing Powerhouse with New Low-level Spillway	52 to 76	Eliminated
8	Existing Powerhouse with ARO	>76	Eliminated
	Variable Pool with Modified Powerhouse		
9	Modified Powerhouse with Existing Spillway	28 to 57	yes
10	Modified Powerhouse with Modified Existing Spillway	38 to 67	Eliminated
11	Modified Powerhouse with New Low-level Spillway	52 to 76	Eliminated
12	Modified Powerhouse with ARO	>76	Eliminated
	Constant Pool with Existing Powerhouse		
13	Modified Powerhouse with Existing Spillway	33	yes
13A	Modified Powerhouse with Existing Spillway – Lower Granite River Only	33	yes
14	Modified Powerhouse with Modified Existing Spillway	43	yes
15	Modified Powerhouse with New Low-level Spillway	52	yes
16	Modified Powerhouse with ARO	52	Eliminated
	Constant Pool with Modified Powerhouse		
17	Modified Powerhouse with Existing Spillway	33	yes
18	Modified Powerhouse with Modified Existing Spillway	43	yes
19	Modified Powerhouse with New Low-level Spillway	52	yes
20	Modified Powerhouse with ARO	52	Eliminated

1/ For reference, a 57-foot drawdown represents an upstream pool at a level equal to the existing spillway crest at Lower Granite Dam.

Dam. It consists of installing a river bypass structure and channel around each of the four lower Snake River dams. The structures would allow the pools to be lowered, and divert the river around each dam in an effort to achieve a near-natural, free-flow river condition. Powerhouse, spillway, and navigation lock operations would cease during the drawdown period. The bypass structures would be designed so the velocities through the structures are acceptable (less than an average of 9 feet per second) for adult fish passage during river flows up to 225,000 cfs.

3.1.5.2 Alternative 5—Existing Powerhouse and Existing Spillway - Variable Pool

This concept would produce variable pool operation with drawdown levels up to 57 feet at Lower Granite, Little Goose, and Lower Monumental Dams; and up to 49 feet at Ice Harbor Dam. The existing powerhouses would be operated to their hydraulic capacity, at pool levels not less than the corresponding existing spillway crest elevations. Flows in excess of powerplant capacity would pass uncontrolled (no gate control) over the spillway. The forebay water surface elevations would fluctuate above the spillway crests, depending on river discharge, and the flow would be split between the powerhouse and the spillways.

The hydraulic capacity for the Ice Harbor powerhouse, operating at spillway crest pool elevation (391), has been estimated to be about 62,000 cfs. At Lower Monumental, Little Goose, and Lower Granite Dams, operating with pool levels at spillway crest elevations of 483, 581, and 681, respectively, the powerhouse hydraulic capacity has been estimated to be about 86,000 cfs. (Note: Hydraulic capacities of powerhouses operating at spillway crest elevations are estimates. Additional studies will be required to refine these estimates. Better estimates will cause corresponding adjustments to numbers presented in the following discussions.)

As the river discharge increases, the pool elevation will increase. The approximate total pool elevation increases as the river flow increases from 62,000 to 225,000 cfs and is about 19 feet for the Ice Harbor pool and 20 feet for the other three reservoirs. At this level (225,000 cfs), the powerhouse hydraulic capacity increases approximately 20 to 25 percent.

3.1.5.3 Alternative 9—Modified Powerhouse and Existing Spillway - Variable Pool

This alternative is the same as alternative 5, except for the powerhouse modifications. Operating existing turbine/generator units at low heads causes a loss in operating efficiency. This occurs because the turbines were designed and built to have peak efficiency at, or near, the heads they would be operated at most of the time. Low efficiency operation due to lower heads can be mitigated wholly, or in part, in various ways. For SCS Phase I, it was assumed that the installation of new turbine-runners would be the option of choice. New turbine-runners can be designed to operate at peak efficiency at a lower head. The blades can be made of stainless steel and the discharge ring overlaid with stainless steel, thereby improving cavitation resistance. Utilizing existing units, efficiency would decrease an average of 5.3 percent. (This assumes that no screening systems, such as submerged traveling screens [STS], are in place. It was unknown how STS affect turbine efficiencies.)

3.1.5.4 Alternative 13—Existing Powerhouse and Existing Spillway - Constant Pool

This alternative proposes a drawdown operation of 33 to 38 feet below normal maximum pools at Lower Granite, Little Goose, and Lower Monumental Dams; and a drawdown of 25 to 30 feet

below normal maximum pool at Ice Harbor Dam. During the drawdown-operating mode, the drawdown pool levels will be maintained at a near constant level (5-foot pool fluctuation).

Water would pass through existing turbines until the hydraulic capacities of the powerplants are reached. River flows in excess of plant hydraulic capacity would then pass over the existing spillways. At these drawdown levels, existing spillway gates could control spill in excess of powerhouse hydraulic capacities. At the 33-foot drawdown level, the hydraulic capacity of the powerplants at Lower Granite (pool elevation 705), Little Goose (pool elevation 605), and Lower Monumental (pool elevation 507) is estimated to be 80,000 cfs at the 25-foot drawdown level (pool elevation 415).

The combined hydraulic capacity of existing powerhouses and spillways at pool levels 24 feet above existing spillway crests is estimated to be 225,000 cfs, assuming spillway gate control is maintained.

3.1.5.5 Alternative 13A—Existing Powerhouse and Existing Spillway - Constant Pool, Lower Granite Only

This alternative describes the same necessary modifications as Alternative 13 with a 33- to 35-foot near constant pool drawdown (5-foot pool fluctuation) at Lower Granite Dam only.

3.1.5.6 Alternative 14—Existing Powerhouse and Modified Existing Spillway - Constant Pool

This alternative proposes to operate the four lower Snake River dams and reservoirs at a level 43 to 48 feet below normal maximum pool levels at Lower Granite, Little Goose, and Lower Monumental Dams; and 35 to 40 feet below the normal maximum pool level at Ice Harbor Dam. To achieve this drawdown level, the existing spillways would be modified by lowering the crests 10 feet. The powerhouses at each lower Snake River dam would be operated to their hydraulic capacity, with excess water passing over the modified existing spillways. During the drawdown operating mode, the drawdown pool levels would be maintained at a near constant level (5-foot pool fluctuation). The reservoir pools would be operated at a drawdown level during the juvenile fish outmigration from April 15 through June 15 or from April 15 through Labor Day. Pools would be returned to normal operating levels for the rest of the year.

At the 43-foot drawdown pool levels, the powerplant hydraulic capacity at Lower Granite (pool elevation 695), Little Goose (pool elevation 595), and Lower Monumental (pool elevation 497) is estimated at 97,000 cfs. The capacity of the Ice Harbor powerplant is estimated at 73,000 cfs at the 35-foot drawdown level (pool elevation 405).

The combined hydraulic capacity of existing powerhouses and modified spillways at the drawdown pool levels (24 feet above the spillway crests) is estimated to be 225,000 cfs, assuming that spillway gate control is maintained.

3.1.5.7 Alternative 15—Existing Powerhouse With New Low-Level Spillway - Constant Pool

This alternative proposes a drawdown operation of 52 to 57 feet below normal maximum pools at Lower Granite, Little Goose, and Lower Monumental Dams; and a drawdown of 43 to 48 feet

below normal maximum pool at Ice Harbor Dam. To achieve this drawdown level, new low-level spillways would be constructed at each dam. The powerhouses at each lower Snake River dam would be operated to their hydraulic capacity, with excess water passing over the new low-level spillways. During the drawdown operating mode, the drawdown pool levels will be maintained at a near constant level (5-foot pool fluctuation).

At the 52-foot drawdown pool levels, the powerplant hydraulic capacity at Lower Granite (pool elevation 686), Little Goose (pool elevation 586), and Lower Monumental (pool elevation 488) is estimated to be 90,000 cfs. The capacity of the Ice Harbor Dam powerplant is estimated to be 67,000 cfs at the 43-foot drawdown level (pool elevation 397).

The combined hydraulic capacity at each project of existing powerhouse and modified spillways at the drawdown pool levels is estimated to be about 225,000 cfs, assuming spillway gate control is maintained.

3.1.5.8 Alternative 17—Modified Powerhouse and Existing Spillway - Constant Pool

This alternative is the same as alternative 13, except for powerhouse modifications described above for alternative 9.

3.1.5.9 Alternative 18—Modified Powerhouse and Modified Existing Spillway - Constant Pool

This alternative is the same as alternative 14, except for the powerhouse modifications described above for alternative 9.

3.1.5.10 Alternative 19—Modified Powerhouse With New Low-Level Spillway - Constant Pool

This alternative is the same as alternative 15, except for the powerhouse modifications described above for alternative 9.

3.2 John Day Reservoir Drawdown

The drawdown of the John Day reservoir to elevation 257 (MOP level) was addressed in NPPC's Strategy for Salmon. This operation would be in effect each year from May 1 to August 31. Lowering the pool levels at the John Day project is being considered as a means of improving the downstream migration of juvenile fish. Normal operating pool level during this period varies, but is about elevation 265. Since the Salmon Summit, an operation at "minimum operating pool" (defined as the lowest level the pool can be operated without impacting irrigation pumping stations) has been employed. This level is elevation 262.5 or higher, as required.

The Corps completed a more detailed study than the one presented for SCS Phase I (Corps, 2000). This study was completed in September 2000. The results of this study are mentioned in Section 2.3.5. Access to the full report is available on the internet at http://www.nwp.usace.army.mil.

3.3 Additional Upstream Storage—Snake River Basin

Analysis of additional storage in the Snake River Basin was included in the SCS in order to provide a comprehensive assessment of potential measures for improving flow (flow augmentation) and salmon survival in the lower Snake River. The objective of flow augmentation is to increase water velocity in an effort to decrease fish travel time to the estuary. Theoretically, this will reduce reservoir-related mortality. With BOR as the lead Federal agency, the analysis was conducted as a separate study in specific response to a request by NPPC.

BOR initiated work on the storage appraisal study in late 1991 with the formation of an appraisal study workgroup with representatives from water-user organizations, fish and wildlife agencies, and other state and Federal agencies. Potential storage sites were identified and study procedures, including site screening criteria, were developed by the study workgroup. In addition, the study work group reviewed interim and final results of the study. Technical studies were completed by BOR and the Corps.

The workgroup completed the inventory of potential sites in July 1992. The workgroup then screened potential sites based on institutional constraints that would prevent development. These constraints included wild and scenic river status, location within a state or national park, and substantial impact to resident fish spawning and rearing habitat. Further screening was then accomplished based on the results of analyses of water supply and site development costs. Following this final screening, the remaining sites were evaluated for their effects on the survival of juvenile salmon and system power costs.

BOR submitted the final report, Snake River Basin Storage Appraisal Study (BOR et al., 1994) to NPPC. The report summarizes the information developed for 11 dam sites. These dam sites, located both on and offstream, could provide water supplies for lower Snake River fish flow augmentation. Because the dam sites are all located above Brownlee Reservoir, they could be used to refill Brownlee Reservoir if Brownlee Reservoir water were released for flow augmentation. The dam sites located close to Brownlee Reservoir could also release water for direct flow augmentation (flow through Brownlee Reservoir).

3.4 Upstream Collection and Conveyance

Upstream collection and conveyance of downstream migrating salmon and steelhead is addressed in NPPC's Strategy for Salmon. Several options for collecting and transporting downstream migrants are also examined in NPPC's Strategy for Salmon. These include alternative collection and diversion sites and transportation methods.

The collection facilities would divert juveniles from the river into holding facilities for barge or net pen transport, or for bypass to a channel or pipe transportation system that would carry the fish below Bonneville Dam. The collection concepts identified include constructing one or more new collection facilities upstream of Lower Granite Dam (near Lewiston, Idaho, and Clarkston, Washington) for juveniles. The diversion point for a bypass channel/pipe was also included in these concepts.

By collecting juvenile fish at the upper end of the Lower Granite Lake and transporting them to below Bonneville Dam, both reservoir and dam passage-related mortality can be eliminated.

Alternative conveyance methods that will be considered include an open canal or pressure pipeline along the river shoreline, an underwater/floating pipeline, and barges.

The migratory canal concept was suggested at the Salmon Summit. Following the summit, a migratory canal committee was formed. Several meetings were held, and were attended by regional interests. The committee formulated some preliminary concepts for this alternative. In addition, information developed by the Idaho National Engineering and Environmental Laboratory (INEEL) for the floating pipeline was incorporated.

3.5 Existing System Improvements

The existing system improvements have been broken down into two separate categories. The first category includes the Lower Snake River Project and McNary Dam and reservoir on the lower Columbia River. The second category includes the remaining projects on the lower Columbia River.

This element of the study defines and evaluates potential improvements to existing systems (both adult and juvenile) that may enhance fish survival by reducing dam passage-related mortality or stress caused during transportation. It was limited to those measures not currently scheduled for implementation.

3.5.1 Lower Snake River Project and McNary

This section addresses system improvements for the lower Snake River. These modifications include actions identified by the NPPC in their Strategy for Salmon, as well as improvements identified by the Corps. The improvements on the lower Snake River have been grouped into four specific categories:

- juvenile passage facilities
- adult passage facilities
- modification of transport
- hatchery modifications.

3.5.1.1 Juvenile Passage Facilities

Potential juvenile facility improvements were identified in NPPC's Strategy for Salmon. The ongoing studies to evaluate these improvements include:

- Evaluate the installation of dispersed release structures at juvenile bypass facility outfalls, or utilize barges/net pens for dispersed release. In addition, dispersed release at Bonneville Dam for juvenile fish transported by truck from the lower Snake River projects was examined.
- Examine extended length screens at Lower Monumental Dam and Ice Harbor Dam for improved fish guidance efficiency (FGE).
- Investigate the construction of a new flume transport system at Lower Granite Dam similar to those found at Little Goose, Lower Monumental, and McNary Dams. The new flume transport system would replace the existing pressure pipe system.

- Evaluate the possibility of improving surface flow conditions in order to collect smolts located in the top portion of the pools (near the dam).

3.5.1.2 Adult Passage Facilities

Potential adult facility improvements are identified in NPPC's Strategy for Salmon (NMFS, 1992). These facility improvements include:

- Evaluate the potential for reducing water temperatures in adult ladders. Shading, sprinkler systems, bubbler systems, and pumping cooler water from the forebay are possible alternatives.
- Investigate the possibility of installing additional collection channels and ladders at the Lower Snake River Project to reduce the delay of adult fish during spill operations.
- Examine the addition of more attraction water to existing ladder and collection systems as a possible enhancement to adult fish passage conditions.
- Examine the possibility of adding vertical slot ladder controls to ladder exits at McNary Dam.

3.5.1.3 Modification of Transport

Potential barge transport improvements include:

- Examine the use of net pens rather than barges.
- Investigate the installation of refrigeration units for collecting transport vessel water.
- Evaluate larger exits for juvenile fish barge releases.
- Examine the use of additional fish barges to aid in reducing transport densities of juvenile fish and the associated stress, reduce forced bypass, and improve direct loading capabilities. The size and number of barges needed will be determined in consultation with the TAG and other fisheries interests. In addition, determine whether or not to replace the existing 23,000-pound capacity barges with larger ones.

3.5.1.4 Hatchery Modifications

Hatchery modifications have been added in an effort to improve the quality of hatchery-reared salmon. By improving hatchery fish quality, there could be a decrease in the negative impacts on wild juvenile salmonids (primarily competition). The following improvements will be evaluated:

- Investigate the installation of gravity-fed, truck-loading capability for smolts in order to improve fish conditions.
- Evaluate the use of additional raceways, or other containment facilities, to reduce fish densities.

3.5.2 Lower Columbia River

In addition to NPPC's Fish and Wildlife Program measure to permit drawdown of the John Day reservoir to MOP, there are a number of project modifications with the potential to enhance the passage survival of migrating adult and juvenile salmonids. Some of these improvements relate to specific measures addressed in the NPPC's Phase II Amendments. Other measures were identified through coordination with regional fishery agencies and Tribes.

This section identifies those possible improvements from the screening process that were selected for study at facilities on the Lower Columbia River. Existing system improvements to be evaluated for possible increases in passage survival were screened to eliminate those measures currently being studied, including Project Improvements for Endangered Species (PIES), and research projects under the Corps' FPDEP (now known as AFEP). Programs normally funded through the Corps' operation and maintenance (O&M) procedure were not included.

3.5.2.1 Extended-length Screens at John Day

Evaluate the benefits of installing extended-length turbine intake guidance screens to intercept a greater depth of water entering the turbine intakes. This will presumably intercept a larger percentage of downstream migrant salmonids, increase FGE, and increase project survival. Also included in this analysis is the identification of a prototype test program and post-construction evaluation of project survival and biological benefits.

3.5.2.2 Juvenile Transportation at John Day

Evaluate the possible transportation of downstream migrants to shorten in-river travel time and avoid bypass predation and reservoir mortality at the two downstream dams (The Dalles and Bonneville).

3.5.2.3 Juvenile Bypass Outfall Locations at Bonneville

Evaluate existing juvenile bypass system (JBS) outfalls, and research possible improvements through relocation of the outfalls. Documentation of existing baseline data is provided to assess problems with passage survival through these systems (Bonneville first and second powerhouses). This study includes a definition of various strategies and fisheries criteria developed since the completion of these facilities.

3.5.2.4 Bonneville First Powerhouse

Evaluate the potential to improve Bonneville First Powerhouse FGE. Increased FGE will guide a larger percentage of downstream migrant juvenile salmonids away from turbine passage, and increase project passage survival.

3.5.2.5 Turbine Passage Survival

Evaluate the potential to make improvements to the turbines. Identify improvements to increase passage survival. Identify potential areas of study with regard to the causal agents of mortality to juvenile fish passage through the turbine environment.

3.5.2.6 Spill Patterns/Fliplips at John Day

Evaluate the potential to modify spill patterns at John Day to optimize operations to improve adult and juvenile passage and survival. Included in this analysis is the evaluation of adding fliplips to the John Day spillway to decrease potential gas supersaturation resulting from high levels of spill.

3.5.2.7 Analysis of Juvenile Downstream Migrant System Facilities at Bonneville First and Second Powerhouses

This study investigates the potential to improve downstream migrant system (DMS) facilities at both powerhouses. Baseline passage survival data are reviewed and possible options as well as ranges of benefits are presented. Changes since the construction of these facilities in JBS fisheries criteria are addressed, and improvements are evaluated for possible benefits in passage survival.

3.5.2.8 The Juvenile Bypass System Outfall Release Alternative (Short-haul Barging)

Evaluate an alternative strategy (short-haul barging) to fixed, single-site juvenile bypass outfall release locations. This study is conceived as a potential outfall/release strategy to decrease indirect mortality at, or near, the JBS outfall release site.

3.5.2.9 Bonneville Package Analyses

Two package analyses were conducted. Package A includes improvements to both powerhouse DMSs, Bonneville First Powerhouse FGE, and the relocation of both outfall sites. Package B includes improvements to both powerhouse DMSs, Bonneville First Powerhouse FGE, and short-haul barging.

3.6 Other Alternatives

The SCS process has been designed to allow the addition of new alternatives because of ongoing work within the region to identify measures and develop plans that promote the recovery of anadromous fish runs in the Columbia River basin, One new alternative, a proposal to construct diking systems within reservoirs to increase flow velocity, was identified.

3.6.1 Montana Plan—Reservoir Diking Systems for Salmon Recovery

A potential alternative to reservoir drawdown that would improve conditions for migrating salmon without the serious impact to other river users is a reservoir diking system. Dikes or levees, built in shallow portions of the reservoir, would reduce the cross-sectional area of the reservoir pool and increase flow velocity.

Reservoir drawdowns reduce area by lowering the elevation of the pool and making the pool shallower. Dikes reduce the cross-sectional area by encroaching on the affected flow area from the sides. This results in a narrower flowing section of water. Unlike major drawdowns, dike systems allow limited elevation changes without dewatering shoreline areas.

Detailed information about the concept and the analysis of this alternative is contained in the report, Reservoir Diking Systems for Salmon Recovery written by Pacific NPPC, Montana in November 1992. The analysis was conducted by the Montana office of NPPC and the Montana Department of Natural Resources using data provided to them by the Corps, Walla Walla District.

4. SCS Phase I – Alternatives Comparison

This section presents the criteria for comparison of the alternatives described in Section 4.

4.1 Comparison Criteria

The criteria used for evaluating the alternatives analyzed in SCS Phase I include:

- technical feasibility
- biological (anadromous fish) effectiveness
- other significant environmental effects
- cost effectiveness
- regional acceptability.

Plan formulation and plan comparison criteria are based on the screening process, as depicted in the decision chart shown in Figure 4-1.

The range of potential actions is compared against each other using the criteria identified above. This evaluation only looked at individual alternatives. There is no comparison of combinations of alternatives.

4.1.1 Technical Feasibility

The feasibility of implementing or constructing an alternative plan, from a technical or engineering perspective, is the starting point for comparing or screening alternatives. If an alternative cannot be implemented it was discarded.

4.1.2 Biological Effectiveness

The effects of the alternatives on salmon survival were analyzed and estimated. Both qualitative and quantitative procedures were used in an effort to estimate survival. Originally, the quantitative estimates were to be based on a life-cycle model called the Stochastic Lifecycle Model (SLCM), developed by Resources for the Future. This life-cycle model has an accompanying juvenile passage model called the Columbia River Salmon Passage (CRiSP) model, developed by the Center for Quantitative Sciences at the University of Washington. The CRiSP model estimates survival for juvenile fish in their migration to a point below Bonneville Dam. The goal was to estimate the effects on survival by measuring returns to the spawning grounds, by species and/or stocks. Unfortunately, due to time constraints, SLCM was not run for the majority of the alternatives, and the quantitative analysis was limited to downstream migrant survival estimates utilizing CRiSP. Due to the project-specific nature of the "System Improvements" (and additional time limitations), CRiSP was not used for the "System Improvements," and the biological effectiveness was limited to a qualitative analysis.

The primary purpose of the salmon models is not to predict actual numbers of surviving juvenile fish or adult fish returning to the future, but to compare the results of different alternatives.

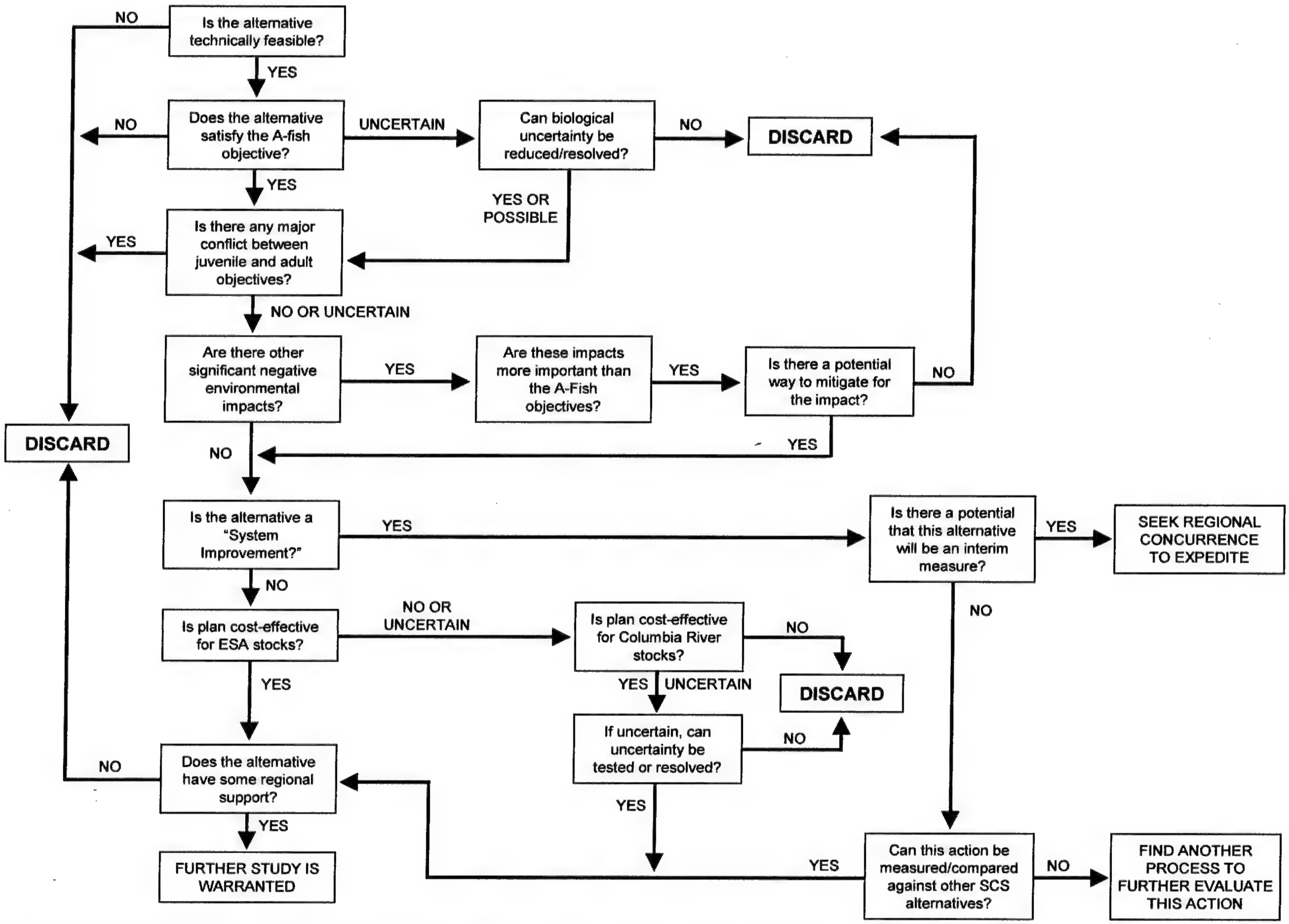

Figure 4-1. Corps' Decision Path for the Snake River Hydropower System Alternatives

For some alternatives, there may be a conflict between making improvements to juvenile and adult migration. If considered to be a significant effect, this could lead to the elimination of an alternative.

4.1.3 Cost Effectiveness Analysis

Cost effectiveness is an evaluation tool, calculated in terms of relative costs needed to achieve a change in salmon survival, in this case juvenile survival to below Bonneville Dam. The analysis looked at each species or stock separately. The cost-effectiveness approach avoided the issue of assigning monetary values to endangered species by comparing alternatives in an attempt to identify the least-cost way to increase survival. This approach did not determine how much improvement of the environmental objective is economically justified, but, rather, it provided information regarding the cost of action for various levels of salmon survival improvement. It is not anticipated that the cost-effectiveness analysis will be able to rank alternatives in terms of economic performance, due to the limited level of analysis performed. However, it will, in general terms, identify some alternatives that are definitely cost effective, and some that are definitely not cost effective.

4.1.4 Regional Acceptability

Regional acceptability for each of these alternatives was assessed. The primary entity for determining regional acceptability is NPPC, but state and local entities, interest groups, industry, and the general public input are also important. The vehicles for obtaining regional input are a 45-day review of this draft report and public information meetings held throughout the region to present the draft results.

4.2 Comparison of Alternatives

4.2.1 Technical Feasibility

Those alternatives that successfully passed the initial screening were considered to be implementable from a technical or engineering standpoint.

4.2.2 Biological Effectiveness

Salmonid passage survival is influenced by many physically and ecologically dynamic processes. Direct effects to mortality (e.g., turbine mortality) can be measured more readily. Indirect effects (i.e., stress responses or delay, causing greater exposure to predators or near-threshold temperatures) can occur in a short time, be accumulated over the length of the migration for a life stage, or not occur until the ocean phase. The significance to overall salmonid population survival of many of these indirect effects are difficult or impossible to measure. This limitation led analysts to formulate educated assumptions for those effects that data indicates may be important to a specific salmonid stock's overall survival. The analytical models were developed for the simulation of juvenile salmonid passage and life-cycle processes. These models were calibrated to historical trends in adult returns and/or physical conditions that were measured during monitoring or experimental conditions. This calibration process was needed for adjusting the model's simulation to recorded conditions and population estimates. This can partially account for the variability and uncertainty in the assumptions and the conditions for which the experimental or monitoring data were collected. Calibration allows for a more accurate simulation of the models, but is not

validation or verification that all assumptions within the models are accurate. For more details on model implementation efforts refer to SCS Phase I report (Corps, 1994).

4.2.2.1 Lower Snake River Drawdown

Based on both a qualitative and quantitative (CRiSP 1.4) analysis, only one of the four reservoir drawdown options on the lower Snake River showed potential benefits to juvenile salmon survival. The CRiSP results for the natural river option showed measurable benefits for spring and summer chinook salmon and steelhead. This same alternative had a negative impact on fall chinook. The near spillway crest drawdown options (33 feet, 43 feet, 52 feet, and variable pool) all showed a potential decline in juvenile survival. A sensitivity analysis, which simulated juvenile survival with both optimistic and pessimistic model parameters, verified these findings. This sensitivity analysis used model parameters that significantly decreased dam passage mortality (e.g., 25 percent increase in FGE over current conditions and only a 2 percent turbine mortality). Even with this condition (which almost eliminates dam passage related mortality), these near spillway crest options still showed declines in survival.

The only other drawdown option to show a possible juvenile survival benefit was the Lower Granite only option, with transport. However, these benefits are marginal (1 to 5 percent) and are only realized under the very optimistic modeling assumptions identified above. This alternative was compared to other collector and transport alternatives and may have potential as an upstream collector and transport option (refer to the following paragraphs).

4.2.2.2 Upstream Collection and Conveyance

A juvenile collector system located at the upper end of the Lower Granite Lake, in combination with barge transportation, has potentially the highest juvenile salmon survival benefits of all of the alternatives evaluated in the SCS Phase I. This estimate was based on the CRiSP model analysis, using the most current transport assumptions of the regional modeling committees.

Quantitative model analyses on the biological benefits for the migratory canal and pipeline options were not prepared. Based upon qualitative reviews of these options within regional technical committee discussions, several biological (salmon-related) concerns were identified. These concerns were substantial enough to eliminate these options from further consideration in Phase II.

4.2.2.3 Additional Upstream Storage

Based on a CRiSP model analysis, none of the storage sites investigated showed measurable benefits to juvenile salmon survival. However, the Phase I analysis may not indicate the true potential of this alternative. The Phase I quantitative evaluation was based on monthly hydroregulation models (HYSSR), rigid flow targets, and lengthy augmentation release periods, which together could understate the benefits to fish migration.

The biological uncertainty inherent in the flow survival relationships used in modeling efforts, as well as other areas of biological uncertainty surrounding the adult and juvenile lifecycle, make it extremely difficult to draw definitive conclusions with respect to the biological efficacy of upstream storage for flow augmentation. Additionally, successive years of consultation with NMFS concerning system operation under ESA have continued to result in increasing requirements for flow augmentation. These requirements are driven by the NMFS assessment that incremental flow

increases are needed and effective as salmon recovery techniques. The need to provide these flows has significant impacts on Dworshak reservoir storage. This is also leading to an increased storage demand on upper Snake River. Further consideration of means to reduce the impact of the water demands on the Columbia River System, particularly existing storage in Idaho, may be prudent.

4.2.2.4 John Day Operation at Minimum Operating Pool

The biological effectiveness of John Day operation at MOP is uncertain from the level of evaluation conducted in SCS Phase I. General flow/survival uncertainties and the magnitude of the physical change in pool level and water travel time contribute to the uncertainty. A more detailed analysis was conducted (Corps, 2000), which resulted in a recommendation to eliminate John Day Drawdown from any further study.

4.2.2.5 System Improvements—Snake River

Salmon survival benefits were not quantified for a majority of the identified improvements. Qualitative analyses on the effects to anadromous fish identified how these improvements would increase the survival of migrating salmon/steelhead. For this reason, it is difficult to extract a precise quantitative biological effectiveness estimate for a single structural improvement at a single dam from the total modeled estimate of survival. This level of detail for proposed system improvements goes beyond the scope of a reconnaissance-level study, especially when no or at least limited empirical data are available to derive an appropriate assumption. Modeling with this level of detail will be attempted for those improvements advanced into Phase II activities.

4.2.2.6 System Improvements—Lower Columbia River

The CRiSP modeling for the John Day transport and turbine improvement measures yielded results that would not be considered significant and were, therefore, inconclusive given the model variability. For turbine improvements, a positive trend in all of the stocks analyzed can be observed from this preliminary analysis. The system survival effects for John Day transport were mixed, depending on stocks. The results were positive for the mid-Columbia summer and fall chinook stocks and negative for spring chinook and steelhead. The extremes, both positive and negative, were somewhat greater than the results for John Day operation at MOP.

For those measures that were evaluated based on project-specific survival, all but one demonstrated a potential to provide modest biological benefits. The exception to this is the improvement of Bonneville First Powerhouse FGE as a stand-alone measure. Guiding additional fish into the bypass system would increase total project mortality because existing bypass system mortality is higher than turbine mortality. This measure should only be considered in conjunction with the other measures at Bonneville.

The biological effectiveness of other measures in combination will be considered in follow-up studies. For instance, extended screens and the spill pattern/fliplip measures at John Day would be considered together in light of fish passage objectives.

4.2.3 Other Significant Environmental Effects

The majority of the available information on the abundance and distribution of native, introduced native, introduced resident fish, and those aquatic invertebrates that support both the resident fish

species and migrating anadromous fish for the lower Snake River reservoirs, has been collected in Lower Granite and Little Goose. Because most of the proposed SCS alternatives are either more specific to sole implementation at Lower Granite, or would be initially implemented at Lower Granite and then adapted to specific conditions at the remaining dams, it can be assumed that the current database is relatively representative for an evaluation of potential environmental effects on resources other than anadromous salmonids. The following bulleted statements summarize the findings of other significant environmental effects:

- Reservoir drawdown could have the most wide-ranging environmental effects of the current reservoir ecosystem
- Upstream collection could be relatively non-intrusive if designed properly, with consideration for resident fish behavior and distribution
- Additional upstream storage would have no perceived negative environmental effects on the lower Snake River reservoir fauna
- Refer to the John Day Drawdown study (Corps, 2000) for explanation of impacts.

No impacts to other environmental resources were identified for the system improvement measures considered for the Lower Columbia dams and reservoirs.

4.2.4 Cost-Effectiveness Analysis

A cost-effectiveness analysis was prepared to assist in determining which alternatives to carry into the SCS Phase II. The analysis compares the costs of proposed alternatives to expected environmental outputs (change in the survival of salmonids to below Bonneville Dam) to determine which alternatives provide the most environmental benefits for the least cost. This information combined with other environmental, social, economic, engineering, and political information served to guide the recommendation process.

As shown in Figure 4-1, the cost effectiveness analysis for Snake River projects was utilized only for alternatives that would:

- be technically feasible
- contribute to satisfying the anadromous fish objective established for the SCS
- not have major conflicts between juvenile and adult objectives
- not have significant other environmental impacts.

Table 4-1 shows the classification of alternatives in terms of cost effectiveness. The alternatives designated as cost effective provide a level of biological output at the lowest cost for the particular species. The alternatives that are not classed as cost effective, either had negative survival percentages or were clearly more costly or less biologically effective than other alternatives. To define the cost-effective measures, this analysis recognized that a great deal of uncertainty surrounds both the cost estimates and the biological model results. In consideration of this uncertainty, some alternatives were classed as possibly cost effective because they may be cost effective within the range of possible project costs and biological effectiveness.

Table 4-1. Summary of Comparison of SCS Phase I Alternatives[1/] page 1 of 2

Measure	Technically Feasible	Biological Effectiveness			Other Environmental Effects	Cost Effectiveness [3/]			Regionally Acceptable[4/]
		S/S[2/] Chinook	Fall Chinook	Steelhead		S/S Chinook	Fall Chinook	Steelhead	
Lower Snake River Drawdown									
Natural River Option	Yes	●	●	●	Yes	◒	○	○	
Variable Pools	Yes	○	○	○	Yes	○	○	○	
33-foot Constant Pool	Yes	○	○	○	Yes	○	○	○	
33-foot Lower Granite Only	Yes	●	●	●	Yes	○	○	○	
43-foot Constant Pool	Yes	○	○	○	Yes	○	○	○	
52-foot Constant Pool	Yes	○	○	○	Yes	○	○	○	
Additional Storage[5/]									
Galloway	Yes	◒	◒	◒	Maybe	○	○	○	
Galloway/Rosevear/ Jacobson Gulch	Yes	◒	◒	◒	Maybe	○	○	○	
Collection and Conveyance	Yes	●	◒	◒	No	●	●	●	
Existing System Improvements – Lower Snake River and McNary Dam									
Dispersed Release	Yes	◒	◒	◒	No				
Extended-Length Screens	Yes	◒	●	◒	No	●	●	○	
LGR Juvenile Facility Mods	Yes	●	●	●	No				
Aux Water Intake - MCN	Yes	◒	●	●	No				
Surface-Oriented Collector	Yes	●	●	●	No				
Net Pens	Yes	○	○	○	No				
Barge Temperature Control	Yes	○	○	○	No				

Table 4-1. Summary of Comparison of SCS Phase I Alternatives[1/] page 2 of 2

Measure	Technically Feasible	Biological Effectiveness			Other Environmental Effects	Cost Effectiveness [1/]			Regionally Acceptable[2/]
		S/S Chinook	Fall Chinook	Steelhead		S/S Chinook	Fall Chinook	Steelhead	
Barge Exits	Yes	●	●	●	No				
New Barges	Yes	◒	●	●	No				
Ladder Temperature Control	Yes	◒	●	●	No				
Additional Adult Ladders	Yes	●	●	●	Maybe				
Ladder Attraction Water	Yes	◒	●	◒	No				
Adult Ladder Exits	Yes	◒	◒	◒	No				
Collection Channel Mods	Yes	○	○	○	No				
Adult Channel Extensions	Maybe	◒	◒	◒	No				
Truck Loading at Hatchery	Yes	◒	◒	◒	No				
Add Raceways – Hatchery	Yes	○	○	○	No				
Stilling Basin Mods	Yes	◒	◒	◒	Maybe				

● Effective ◒ Maybe Effective ○ Not Effective

1/ This table has no entries in the required Regional Acceptability column because the SCS Phase I study report was not prepared as a final document and the files are not retrievable.

2/ S/S = Spring/Summer

3/ Survival modeling was not done for alternatives with blank cells.

4/ Regional acceptability to be determined through the draft report regional review.

5/ Both potential projects have been identified as possible sources of additional storage. Although these have been evaluated, neither project exists at the present time.

4.2.5 Regional Acceptability

It was intended that information received during the 45-day regional review of the draft Phase I report would be used to determine regional acceptability for the SCS alternatives. This effect was never fully investigated and, therefore, Regional Acceptability is not considered in the Summary Comparison of Alternatives (see Table 4-1).

4.3 Summary of Comparisons

Based on the performance against the five established criteria, a summary of the preliminary observations or findings from the comparison of the alternatives is presented below. Table 4-1 shows a consumer report type of summary of the Phase I alternatives. In this table, the biological and cost effectiveness are shown in terms of effective, possibly effective, and not effective. This general type of evaluation was identified because of the significant amount of uncertainty associated with the evaluations, particularly with respect to the biological effectiveness of the anadromous fish benefits. This type of comparison is considered to be sufficient for reconnaissance evaluations with the objective of identifying alternatives that may have promise and warrant further, more detailed study.

4.4 Preliminary Conclusions

The function of the Phase I study was to: 1) screen out alternatives that showed little or no potential to improve salmon migration conditions, 2) screen out alternatives that were not cost effective, and 3) identify alternatives that showed some promise in this regard. Due to the regional controversy and uncertainty over the flow survival relationship, juvenile fish transportation program, estuary uncertainties, salmon survival simulation model limitations, and other areas, it is important that both in-river migration and transportation alternatives be further evaluated in Phase II.

These preliminary conclusions were drawn with full recognition that a high degree of uncertainty concerning the salmon life-cycle biology exists, and there is controversy surrounding the relative merits of transport compared to in-river migration. Knowledge of biological parameters in the estuary portion of the juvenile migration is severely lacking. This could be of significance in evaluating various recovery alternatives. Efforts are underway to identify potential tests and research to reduce these levels of uncertainty.

4.4.1 Lower Snake River Drawdown

Only the Natural River Drawdown Option warrants further analysis in Phase II. This determination is based on the fact that this option was the only four-reservoir drawdown alternative to identify any anadromous fish benefits.

Two mathematical models (PAM and CRiSP) were used to attempt to quantify the potential relative juvenile salmon benefits of reservoir drawdown alternatives. Based on these models, the Natural River Drawdown Option was the only four-reservoir drawdown alternative to show a consistent potential benefit for anadromous fish, although the benefits were limited to spring and summer chinook, and no potential benefits were identified for fall chinook or steelhead. The other four-reservoir drawdown alternatives, which are considered to be near spillway crest, showed negative impacts to all juvenile stocks investigated. Other qualitative evaluation supported this

determination. The models were run with a range of assumptions as a sensitivity analysis, which verified the results.

The only near spillway crest drawdown alternative to show possible marginal benefits for all stocks was the Lower Granite Only Option with transport. The CRiSP model showed only a marginal potential benefit in juvenile survival for this alternative, but these results could change with dam passage parameters adjusted to reflect worsened conditions for collection and bypass hydraulics during a drawdown. Survival could be substantially worse with these hydraulic changes associated with drawdown rather than under existing conditions. Although this alternative includes drawdown, it is more closely associated with the upstream collection and conveyance alternative.

The relationship used with the existing mathematical models assumed that increasing flows and velocities directly reduce juvenile fish travel time, thereby, reducing their reservoir-related mortality and increasing survival. This increase in reservoir survival for the near spillway crest alternative is not enough to overcome other factors reducing survival during migration through the lower Snake River (i.e., increased mortality from turbines, spill, and bypass operations). In addition, the fish are then subjected to reservoir and dam mortality through the four dams and reservoirs on the lower Columbia River. Unless actions are taken on the lower Columbia River to significantly reduce reservoir and/or dam-related mortality, the near spillway crest drawdowns on the lower Snake River do not appear to be an effective action to improve system-wide migration conditions for juvenile salmon. The Natural River Drawdown Option eliminates the effects of the four lower Snake dams, which is enough to potentially offset the increased mortality through the lower Columbia River.

The Natural River Drawdown Option was one of the most expensive alternatives evaluated. The implementation timeframes are also extremely long. The estimated construction cost is $4.9 billion (including inflation). The time required to implement this alternative is 17 years, starting from the date authorization is enacted and construction funds are appropriated, to the completion of the construction.

4.4.2 John Day Operation at Elevation 257

The results of the Phase I study provide little information to reduce uncertainties surrounding the biological effectiveness of the proposed operation. This uncertainty results from general flow/survival issues as well as the relatively small physical change in pool levels and water travel time that would be achieved by the operation. Refer to the John Day Drawdown study for results and recommendations (Corps, 2000).

4.4.3 Additional Upstream Storage–Snake River Basin

The development of additional water storage sites within the Snake River Basin warrants further evaluation in SCS Phase II. This conclusion is based on the potential of these sites as effective and economical means of augmenting streamflows in the lower Snake River. Although additional augmentation storage showed no measurable quantifiable biological benefit in terms of improving salmon survival (as determined using CRiSP), the Phase I analysis may not indicate the true potential of this alternative. The Phase I quantitative evaluation was based on monthly hydroregulation models (HYSSR), rigid flow targets, and lengthy augmentation release periods, which together could understate the benefits to fish migration.

The biological uncertainty inherent in the flow survival relationships used in modeling efforts, as well as other areas of biological uncertainty surrounding the adult and juvenile lifecycle, make it extremely difficult to draw definitive conclusions with respect to the biological efficacy of upstream storage for flow augmentation. Additionally, successive years of consultation with NMFS concerning system operation under ESA have continued to result in increasing requirements for flow augmentation. These requirements are driven by the NMFS assessment that incremental flow increases are needed and effective as salmon recovery techniques. The need to provide these flows is stressing the use of the Dworshak reservoir storage. This is also leading to an increased storage demand on the upper Snake River. Further consideration of a means to reduce the impact of the water demands on the Columbia River system, particularly existing storage in Idaho, may be prudent.

If public review and regional comment provide compelling support for this approach, there appears to be potential for additional storage to yield benefits in the following areas:

- benefits to juvenile migration above Lower Granite Lake for both spring/summer and fall chinook
- use of additional upstream storage primarily for spring/summer chinook flow augmentation thus saving Dworshak storage for fall chinook temperature control and flow augmentation
- pulsing reservoir flow releases (during peak migration periods)
- flow augmentation during critical (low) water years
- flow augmentation in combination with upstream collector(s) and barge transport
- flood control storage transfers from the Brownlee reservoir to new storage sites to create additional flow releases from Brownlee. If this alternative is evaluated further, it would be wise to expand the evaluation to examine reallocation of existing storage to fish flow augmentation purposes.

4.4.4 Upstream Collector and Conveyance

The option of an upstream collector and barge transportation warranted further study in Phase II based on potential anadromous fish survival benefits, cost effectiveness, and NMFS Recovery Team draft findings. The estimated biological benefits associated with the collector, coupled with barge transportation, appear to be the highest of all the alternatives being evaluated. This survival estimate is generally consistent with the analysis prepared by the NMFS Recovery Team (October 1993). The other biological effects (resident fish and wildlife impacts) do not appear to be significant with this alternative. Further study could be pursued in Phase II, provided regional review and comment indicates support for more detailed evaluation.

The option of Lower Granite drawdown with barge transportation was compared to other upstream collector and barge transport options. It would appear that, based on cost effectiveness, further study of this option is not justified. The upstream collector options had much higher juvenile salmon survival rates and lower implementation costs.

The migratory canal and pipeline proposals should be eliminated from further consideration due to biological concerns and uncertainties.

4.4.5 System Improvements–Lower Columbia River

Qualitative considerations and the preliminary quantitative analysis suggested that there is sufficient justification to continue study of these measures. The FGE improvements at Bonneville First Powerhouse warranted further consideration but only in conjunction with other bypass improvements. The process for moving forward could vary depending on the measure. In general, a separate process for the lower Columbia facilities would appear to be the most effective method to move forward beyond the SCS Phase I. This is a preliminary conclusion subject to regional input, which would allow proceeding in a more timely manner with studies and implementation of feasible measures to improve the passage survival for mid- and lower-Columbia River stocks. This course of action recognizes the long-term nature of implementation of major modifications on the Snake River. It also recognizes that measures implemented for Columbia stocks would similarly benefit listed Snake River stocks if future decisions led to in-river migration for these stocks.

The John Day extended screens and spill patterns, and the Bonneville DMS and outfall measures, could move forward into design studies as the technology is known and the engineering and biological feasibility would not be in question. There could be a question of alternative technology with regard to extended screens, which should be addressed. The addition of fliplips at John Day could be evaluated in conjunction with the testing required for spill patterns and in consideration of the extended-screen measure. The Bonneville outfalls measure would require a research program to optimize the location for placement of the outfalls in conjunction with the design studies. A minimum 2-year research program is anticipated. Testing of alternative outfall strategies (short-haul barging) could also be conducted in association with this research.

The Bonneville First Powerhouse FGE measure could be carried forward as a feasibility study. It is believed that there may be advantages to considering the feasibility of alternative bypass technologies in conjunction with studies to modify the existing first powerhouse fish guidance system.

The transport measures (John Day transport and short-haul barging) would require research to ascertain and demonstrate the biological feasibility and determine regional support.

Turbine improvements is a research program that would include laboratory studies, numerical analysis, turbine design, and prototype testing. The purpose would be to study the various causal agents of juvenile fish injury and mortality through turbines as well as to determine the feasibility of designing modifications or new turbine designs to reduce these effects. The outcome could lead to replacement of all or some of the turbines, either through a specific turbine replacement program to improve turbine passage survival, or through incorporation of new designs into future powerhouse rehabilitation programs.

5. SCS Phase II – Interim Status Report

On March 2, 1995, NMFS issued its 1995 Biological Opinion (NMFS, 1999a). The Biological Opinion established measures necessary for the survival and recovery of Snake River salmon stocks listed under the ESA. Also identified was a specific decision path for the implementation of long-term alternatives (see Figure 5-1). This path identified two major decision points. The first decision point occurred in 1996, and required an interim status report with a preliminary decision regarding the selection of one of three drawdown alternatives for the Lower Snake River Project in order to proceed with detailed engineering or the elimination of any further consideration of drawdown. If a decision on drawdown could not be made in 1996, a second decision point was identified to occur in 1999. The 1999 decision point required a final plan for drawdown or surface bypass and collection to be selected along with feasibility evaluations and NEPA documentation to be completed.

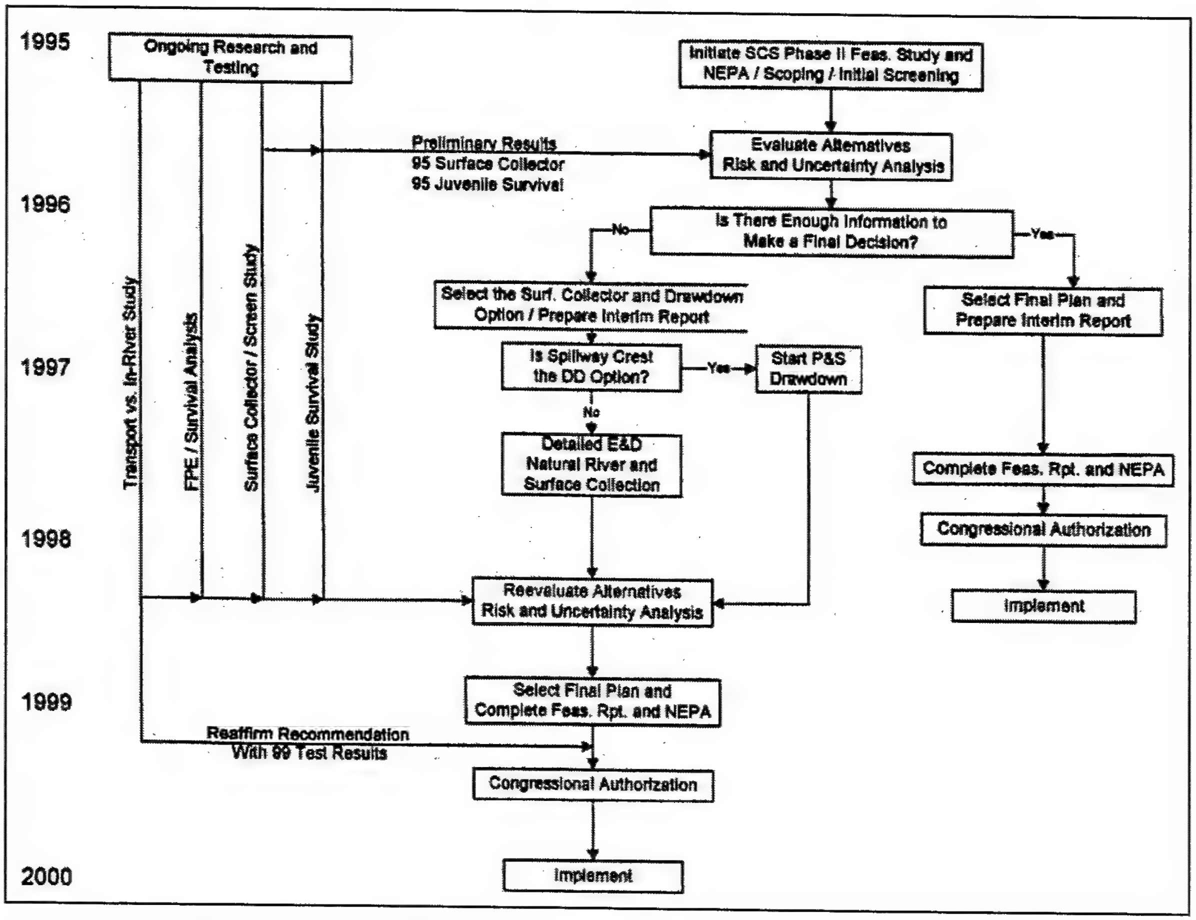

Figure 5-1. NMFS Decision Path

Source: NMFS, 1995

The measures considered in the Phase II analysis were generated from the SCS Phase I effort, as well as those identified in the NMFS 1995 Biological Opinion and Proposed Recovery Plan for Snake River Salmon (NMFS, 1995b). These measures include drawdown of the lower Snake River reservoirs and improvements to the juvenile salmon passage system (primarily surface bypass).

The SCS Phase II analyses focused on measures that could be implemented on the Lower Snake River Project. Alternatives identified for the lower Columbia River will be addressed under other studies being conducted either in conjunction with the lower Snake River studies or on a schedule fulfilling recommendations in the NMFS 1995 Biological Opinion.

This chapter presents the information from the Interim Status Report (1996) on both a discussion of alternatives selected for analysis and alternatives comparison process.

5.1 Discussion of Alternatives

In response to recommendations in the NMFS 1995 Biological Opinion, the Corps initiated and completed an interim evaluation report on three drawdown alternatives (natural river drawdown, spillway crest drawdown, and surface bypass) and surface bypass options. The evaluation was accomplished by:

- identifying, investigating, and compiling data, activities, and issues associated with each alternative
- developing conceptual designs for drawdown
- developing cost estimates
- engineering, testing, and evaluating a prototype surface collector
- assessing the biological effects of alternatives, using both existing and new data
- qualitatively evaluating all other effects of drawdown and surface bypass alternatives.

5.1.1 Alternative Screening

This section describes the process used for narrowing the scope of the feasibility study. The steps required to formulate the solution to a problem are basic to any planning process. The procedure used for this feasibility study follows the general requirements of that formulation process. Plan formulation includes:

- an assessment of the problems and opportunities
- the identification of existing conditions and future conditions without the project
- a description of any constraints
- development, screening, analysis, and selection of the final plan chosen to provide the best solutions to the problem. The problem assessment, identification, and constraint portions of this process were completed during Phase I.

The feasibility study is being prepared in response to the NMFS 1995 Biological Opinion, Reasonable and Prudent Alternative Number 10, regarding implementation of long-term measures. Two decision points were identified. NMFS 1995 Biological Opinion identified a

decision point in 1996 (see Figure 5-1). The Biological Opinion provides the following guidance for this decision point:

> "By mid-1996 the reasonable and prudent alternative calls for the COE to have completed an interim evaluation report (Interim Status Report [Corps, 1996a]) on natural river drawdown, spillway crest drawdown, and surface collectors. The COE should then proceed in 1996 with the engineering and design work on the preferred drawdown alternative and surface collectors..."

A final selection of the preferred hydrosystem configuration and operation is identified for 1999.

The NMFS 1995 Biological Opinion has already identified early requirements of the planning process, including the identification of problems for the alternatives under consideration. The Corps' Interim Status Report, which was prepared for the 1996 decision point, explained how the alternatives were analyzed and eliminated, through screening, to meet the requirements of the NMFS 1995 Biological Opinion for the 1996 decision point. Selection of the final plan will not be accomplished, however, until completion of the feasibility study process.

5.1.1.1 Long-term System Configuration Options

In consideration of long-term system changes, there are generally three courses available for the migration of juvenile salmon through the lower Snake River:

- juveniles can be collected and transported by barge or truck to below Bonneville Dam
- juvenile salmon can be left in-river
- a combination of transport and in-river can be used. The in-river concept has two options; drawdown or non-drawdown structural changes.

Collection and Transportation

Corps and NMFS, in cooperation with fish agencies and the Tribes, developed the Juvenile Fish Transportation Program during the mid-1970s as an emergency measure to compensate for low water conditions. At the collector dams, screens in the turbine intakes guide the fish to collection systems, gather the smolts, and direct them to holding facilities. At appropriate intervals, the fish are loaded onto barges or trucks and transported downstream. Barges constantly circulate river water, allowing the smolts to imprint on the chemical composition of the water, thus, enabling them to locate their natal streams upon their return from the ocean. The barges also dissipate high dissolved gas levels in the river water.

Alternatives considered for the improvement of the transportation measure included improved collection facilities, surface collection, guidance curtains, the addition of new transport barges for direct barge loading and to allow sorting by size, new extended-length screens at the turbine intakes, and reduced spill. The modification of both procedures and facilities was planned. Continued monitoring and evaluation was also planned.

In-river Migration

There were two options for in-river migration: 1) some form of reservoir drawdown, and 2) non-drawdown structural or operational changes (e.g., surface bypass collection or spill).

Drawdown

Drawdown options for the Lower Snake River Project include:

- spillway crest, seasonal (4½ months)
- natural river, seasonal (4½ months)
- natural river, permanent.

The concept of reservoir drawdown was originally aimed at eliminating reservoir-related mortality (i.e., predation, the incidence of disease, and physiological conditioning for transition from freshwater to a saltwater environment). The relationship between flow and survival is fundamental to the benefits of drawdown. The relationship between flow, velocity, fish travel time, and survival is generally supported by the region.

The Natural River Drawdown Option lowers reservoirs approximately 100 feet and essentially eliminates the four reservoirs on the lower Snake River, thus, returning this 140-mile stretch of the river to an unobstructed, yet controlled conditions. This option would not only reduce reservoir-related mortality, but would also completely eliminate dam-related mortality in the lower Snake River. The near spillway crest option is a mid-level drawdown of approximately 38 to 50 feet.

Non-drawdown

If not collected and transported from the lower Snake River dams or McNary Dam, juvenile salmon originating above Lower Granite Dam must swim through the four reservoirs and dams on the lower Snake River as well as through four reservoirs and dams on the lower Columbia River to reach the estuary. Juveniles not transported by barge or truck pass through turbines, screens, bypass outfalls, or over spillways. All eight lower Columbia and Snake River dams are equipped with some type of bypass system for downstream migrants.

Non-drawdown structural or operational methods investigated to improve the in-river migration of juvenile salmon include surface bypass collectors (SBC), fliplips, spillway baffles, increased spill, increased flow from storage, spillway modifications, turbine modifications, fish guidance curtains, and sound attraction.

Mixed Strategies

A third option for improving juvenile salmon survival is to employ a combination of transportation and in-river options. This mixed strategy approach would allow some fish to be collected and transported. Remaining fish would be collected through bypass systems and directed back into the river, allowed to go over the spillways, or allowed to go through the turbines during operation.

5.1.1.2 Interim Status Report Screening

A traditional method was used to screen only drawdown options for the 1996 decision point. Evaluation criteria were selected and values were established. Based on analysis, each alternative was judged against the criteria. The alternatives were then ranked, and the drawdown alternative with the highest ranking was recommended for further study.

Other measures were also investigated in the feasibility study process. Multiple alternatives for SBC were considered and developed, but the testing and development of these alternatives was too preliminary to be screened from the process at this time. Further development and screening of options for SBC will occur in the future years of the feasibility study process in order to meet the 1999 decision date specified by the NMFS 1995 Biological Opinion.

The other alternative considered, compared, and measured later in the process was the "existing condition," or what is known as the "without project condition." This alternative includes existing programs, equipment, and operations, as well as scheduled modifications. Although it was not the function of the Interim Status Report to screen or compare alternatives to existing programs, some general discussion on the existing direction is provided as framework for the ongoing study.

Evaluation Criteria

Technical Feasibility

Technical feasibility is the likelihood and workability of constructing and implementing an alternative plan from a technical or engineering perspective. If a structural alternative cannot be designed and constructed within the scope and purpose of the project, it is removed from further consideration.

Biological Effectiveness

Biological effectiveness includes the qualitative and quantitative evaluation of salmon survival benefits for the alternatives. Model results, as well as data taken from ongoing research work, will be used to determine the alternative with the greatest possibility of improving salmon survival.

Other Environmental Effects

Other environmental effects must also be considered. Impacts to resident fish, other aquatic organisms, terrestrial ecology, air and water quality, and cultural resources will be considered.

Cost Effectiveness

Cost effectiveness is an evaluation tool, calculated in terms of relative costs needed to achieve a change in salmon survival. The analysis will include a comparison of the cost of each drawdown alternative, while also considering the biological effectiveness for salmon survival improvements.

New economic studies were not developed for the Interim Status Report. The SOR EIS (BPA et al., 1995) information was adopted, with minor changes, to bring costs to present price levels. However, SOR power costs are not useable for this analysis because of changes in base case operation, assumptions used in the SOR drawdown options that are not appropriate for these drawdown alternatives, and changes in the value of power. Because of the expected magnitude of change of power costs associated with drawdown alternatives, the inability to incorporate power impacts into this study limits the completeness of the analysis and the ability to complete cost-effectiveness comparisons.

Regional Acceptability

Regional acceptability is based on public, agency, and tribal comments received during past reviews of the Corps' work. This is also based on the guidance from NMFS, NPPC, and the System Configuration Team (SCT).

5.2 Existing Fish Passage Systems

Long-term decisions regarding the best operation and configuration for the Lower Snake River Project were evaluated against the current fish programs. Current project operations and facilities found on the Lower Snake River Project can be identified as the "existing condition" or "base case." When these actions (including existing programs, equipment, and operation of the dams and reservoirs) are considered with future planned work for these features, exclusive of the proposed alternative actions (in this case drawdown or SBC), it is more accurately referred to as the "without project condition."

Existing fish passage systems include the bypass and transport of juvenile salmonids, operation of the facilities to support flow augmentation from the upper Snake River and Dworshak Dam, as well as spill to in-river migration. In addition, there are continued improvements to turbine passage with the use of screens as well as turbine operations to improve survival of unguided fish.

5.3 Drawdown Alternatives

The idea of drawing down reservoirs below design operational levels during the salmon migration season first surfaced at the regional Salmon Summit meetings, convened by Senator Mark Hatfield in 1990, in response to the proposed ESA listing of Snake River salmon stocks. The idea was further pursued in NPPC's Strategy for Salmon (NPPC, 1992).

The speed of water flowing through the lower Snake River system, and travel time through the reservoirs for juvenile salmon, have been identified as possible factors in juvenile fish survival. The relationship between water travel time, migration time, and fish survival is a general one, and is not considered to be a quantitative expression. Migration research supporting this general relationship applies primarily to spring and summer chinook salmon. One method for achieving decreased water travel time involves reducing the reservoir cross-sectional area by operating the reservoirs at lower water surface elevations. This proposed operation would occur during the annual juvenile migration period. Drawdown is considered an effort to keep juvenile salmon in-river, thus, replacing the need for the existing transportation program (at least on the lower Snake River).

The SCS Phase I presented 22 different potential drawdown alternatives. These alternatives are defined by drawdown elevation as well as by features at each dam that would need to be modified or newly constructed to achieve the appropriate drawdown level. To reduce the number of alternatives, the Phase I study screened conceptual designs based on engineering feasibility, biological effectiveness, and regional acceptability. The NMFS 1995 Biological Opinion supported findings from the Phase I study. Three of the potential drawdown alternatives were carried into Phase II. These three alternatives are described within this section. For more details on the alternatives considered, refer to the Interim Status Report (Corps, 1996a).

5.3.1 Spillway Crest Drawdown

5.3.1.1 Description

This alternative proposed a drawdown operation of 33 to 38 feet below normal maximum pools at Lower Granite, Little Goose, and Lower Monumental Dams; and a drawdown of 25 to 50 feet below normal operation at Ice Harbor Dam. During the drawdown operating mode, pool levels would be maintained at a near constant level operating at this drawdown level throughout the juvenile fish outmigration (April 15 through Labor Day). Pools would be returned to normal operating levels for the rest of the year.

Water would pass through existing turbines until the hydraulic capacities of the powerplants were reached. River flows in excess of the powerhouse capacity would then pass through the existing spillways. At these drawdown levels, spill in excess of powerhouse hydraulic capacities could be controlled by existing spillway gates.

5.3.1.2 Operation

The Lower Snake River Project would begin drafting no later than March 29 in order to reach the target drawdown elevation by April 15 each year. Drawdown pools must be achieved prior to the arrival of a large number of juvenile fish because the low-level bypass systems will not be operational until drawdown pool levels are reached. The date computed to begin drawdown assumes full pools initially, a maximum drawdown rate of 2 feet per day, and average inflows to Lower Granite Lake of less than 225,000 cfs. The average discharge above inflows required at Lower Granite, Little Goose, Lower Monumental, and Ice Harbor Dams is 6,800 cfs, 15,600 cfs, 21,000 cfs, and 26,400 cfs, respectively. The discharges would be highest at the beginning of the drawdown period. Peak discharges above the inflows at the four dams would be 8,400 cfs, 18,300 cfs, 27,000 cfs, and 35,300 cfs, respectively. The total reservoir system storage to be evacuated from full pool elevations to drawdown elevations is estimated to be 900,000 acre-feet.

If reservoirs were maintained at drawdown levels from April 15 to Labor Day, reservoir refill would begin around September 5. Refill would take approximately 25 days provided average inflows of 30,000 cfs were achieved. The time for refill would vary depending on inflows. Given maximum inflows of record (40,000 cfs), refill would take approximately 16 days. During low flow years, when average inflows can drop to around 20,000 cfs, refill could take up to 54 days. Shorter refill times can be achieved by drafting upstream storage, but a large portion of the September inflows into Lower Granite Lake come from drafts of the Dworshak reservoir already. Following the 1995 Biological Opinion operational recommendations, the Dworshak reservoir would be approximately 80 feet from full at the beginning of September, with a minimum draft

elevation of 1,520 feet. These computations assume minimum project releases of 11,500 cfs during the refill period. The reservoirs would probably be filled in the following order: Ice Harbor, Lower Monumental, Little Goose, and Lower Granite. However, the order of refill would not generally impact the refill time.

5.3.1.3 Required Modifications

The spillway crest alternative would require structural modifications to the four lower Snake River dams. These modifications are described below. These modifications include juvenile bypass and adult systems, spillway stilling basins, earth embankments, and other miscellaneous features. Information provided on this drawdown alternative is considered reconnaissance-level and is, therefore, preliminary. Features such as improvements for the efficiency of turbine operation at low forebay elevations, modifications to resolve interim passage problems, and structural changes to mitigate the effects of extended construction periods were beyond the level of detail in the early phase of this study.

5.3.2 Natural River Annual Operation (Seasonal) Alternative

5.3.2.1 Description

This alternative would produce a near-natural, pre-dam river flow condition on the lower Snake River during a portion of the year. It consists of installing a river bypass structure and channel around each of the four lower Snake River dams. The structures would allow the pools to be lowered, and divert the river around each dam in an effort to achieve a near free-flow river condition. For river flows of 20,000 cfs, the total drawdown below normal maximum pool levels would be approximately 115 feet at Lower Granite, 114 feet at Little Goose, 108 feet at Lower Monumental, and 97 feet at Ice Harbor. The reservoirs would be operated at a drawdown level during the juvenile fish outmigration (April 15 through Labor Day), and pools would be returned to normal operating levels for the rest of the year. Powerhouse, spillway, and navigation lock operations would cease during the drawdown period. The bypass structure would be designed so that velocities through the structures are acceptable for adult fish passage during river flows up to 225,000 cfs.

5.3.2.2 Operation

Drawdown

The existing powerhouses and spillways would be used to lower upstream pool levels from full pool levels to near existing spillway crest elevations. Below spillway crest elevations, the powerhouses and existing spillways would be inoperable. To further lower the pool to near-natural river elevations, tainter gates on new flow control structures would be opened, throttling the flow to allow a controlled lowering of the upstream pool. As the pool reaches the near-natural river level, the tainter gates would be raised completely out of the water. Reservoir drafting would begin no later than February 16 in order to achieve the near-natural flow condition by April 15 each year. Reservoir drafting would be limited to 2 feet per day. Inflows to Lower Granite Lake during this period average about 60,000 cfs. For inflows up to 190,000 cfs, the average discharge above inflows required at Lower Granite, Little Goose, Lower

Monumental, and Ice Harbor would be 3,800 cfs, 8,300 cfs, 11,300 cfs, and 14,500 cfs, respectively. The discharges will be highest at the beginning of the drawdown period. Peak discharges above inflows at the four projects would be 8,400 cfs, 18,300 cfs, 27,000 cfs, and 35,300 cfs, respectively. The total reservoir system storage evacuated during the drawdown is estimated to be 1,663,500 acre-feet. The drawdown time from full pool levels is limited only by the rate of drawdown (2 feet per day), provided that average Lower Granite inflows are less than 210,000 cfs. The maximum mean daily inflow to Lower Granite, for the period between October 1976 and September 1991, was 166,200 cfs.

The period of transition between normal and drawdown operations would begin prior to the juvenile outmigration period. This would preclude the need for a low-level juvenile powerhouse bypass system. Existing adult fish facilities would be modified to allow adults to pass the dam during the transition period when the powerhouse is in use. When the pool is between spillway crest elevations and on the verge of a near-natural river, the passage of adult fish would not be possible. Water flowing under the tainter gates would create velocities too high for adult fish to negotiate. Adult passage would be possible after the tainter gates are completely raised from the water.

Refill

Following the drawdown period, regulated discharges would be reduced, allowing the reservoir to refill. Adult passage will again not be possible until the reservoir pools reach spillway crest elevations, and existing ladder systems and powerhouses are once again operational. If reservoirs are maintained at near-natural river elevations from April 15 to after Labor Day, refill of the reservoirs would begin around September 5. Refill would take approximately 46 days, given average inflows of 30,000 cfs. The time for refill would vary depending on inflows. If maximum inflows of record (40,000 cfs) are achieved, refill could occur in as quickly as 29 days. If the refill takes place during a low water year, when average inflows may drop to as low as 18,000 cfs, the refill period could take up to 129 days. Shorter refill times can be achieved by drafting upstream storage, but a large portion of the September inflows into the Lower Granite Lake already come from drafts of the Dworshak reservoir. Dworshak can be drafted up to 80 feet from full pool during September. These computations assume minimum project releases at all four lower Snake River dams of 11,500 cfs during the refill period. The reservoirs would likely be filled in the following order: Ice Harbor, Lower Monumental, Little Goose, and Lower Granite. However, the order of refill would not usually impact the time for refill.

5.3.2.3 Required Modifications

This alternative would require major physical changes to the four lower Snake River dams. The installation of bypass and non-overflow structures and the excavation of the new river approach channels (both upstream and downstream of the new bypass structures) would be required. Installation would require the relocation of roads and railroads and the removal of existing North Shore non-overflow embankments at Little Goose and Lower Granite Dams. At Lower

Monumental and Ice Harbor Dams, major channel excavations would be required along the south shores of the dam. Additionally, modifications must be made to existing adult facilities, spillway stilling basins, earth embankments, and other miscellaneous features. Information provided on

this drawdown alternative is considered reconnaissance-level and is, therefore, preliminary. Features such as improvements for the efficiency of turbine operation at low forebay elevations during the lowering of reservoirs and structural changes for mitigation of the effects of extended construction periods were beyond the level of detail in the early phase of the study.

5.3.3 Natural River Year Round (Permanent) Alternative

5.3.3.1 Description

This alternative would produce a permanent near-natural river condition on the lower Snake River. The permanent drawdown alternative was not included in the original alternatives identified in the SCS Phase I Report. This alternative was added to the study when the alternative was included as a study recommendation by NMFS in their 1995 Biological Opinion. This alternative has received development since spring of 1995. The following description is based on limited or reconnaissance-level information only.

The permanent near-natural river scenario differs from all of the other drawdown scenarios. Structural modifications would be undertaken at the dams, allowing reservoirs to be drained, and resulting in a free-flowing, yet controlled river that would remain unimpounded. For flows of 20,000 cfs, the total drawdown below normal maximum pool levels would be approximately 115 feet at Lower Granite, 114 feet at Little Goose, 108 feet at Lower Monumental, and 97 feet at Ice Harbor. The permanent near-natural river option would remove the earthen embankment section at Lower Granite and Little Goose, and form a channel around Lower Monumental and Ice Harbor Dams. It would be necessary to develop an appropriate channel around the powerhouses, spillways, and navigation locks. It would also be necessary to install protection measures on these remaining structures.

Several issues have been determined to be critical and integral in formulating this concept. Modifications to structures would be done in such a manner that the structures could be restored to operating conditions with later modifications. This requires the protection of structures from near-natural river flows, and the decommissioning and storing equipment for possible reactivation. Secondly, construction operations are phased so that power production, navigation, and fish migration can continue until the last possible period.

5.3.3.2 Operation

The powerhouses and spillways would be used to lower upstream pool levels from full pools to near existing spillway crest elevations. Below spillway crest, the current powerhouses and existing spillways would become inoperable. Additionally, based on a drawdown rate of 2 feet per day, current facilities to pass juvenile and adult fish would be inoperable within a few days to 2 weeks of initiating the drawdown process.

Reservoir drawdown below spillway crest is not possible without some structural modifications because none of the Snake River dams were constructed with a low-level outlet. Several options were considered to evacuate the reservoirs below spillway crest; including mining through the concrete of the spillway bays or the powerhouse, excavating through the embankment section, and modifying the navigation lock to discharge low-level flows. The most feasible, from an

engineering feasibility and economic perspective, is installing an outlet through one or two powerhouse bays.

It is necessary to provide an outlet for approximately 20,000 cfs. This is the normal base flow for the Snake River during late fall and winter. It is estimated that a 30-foot-diameter outlet through one powerhouse unit will discharge approximately 11,000 to 15,000 cfs, depending on the water level in the forebay. Because each powerhouse bay is designed so that upstream and downstream bulkheads can be installed to stop flow, construction could proceed without the construction of independent cofferdams. Construction could proceed well in advance of the drawdown operation with minimal impact to concurrent power generation, navigation, and fish migration.

Although the construction of outlets through the powerhouse would allow drawdown of the majority of the reservoir, some ponding would still exist behind the earthen embankments. After draining as much water as possible through the new outlets, a section of the embankments would be removed to allow flow down to the riverbed.

Reservoir drafting would be limited to 2 feet per day, requiring 58 days to draft 115 feet below full pool. The total reservoir storage that would be evacuated during drawdown would be 1,663,500 acre-feet.

5.3.3.3 Required Modifications

A number of structural modifications to the features of each of the dams would be necessary for a permanent drawdown. Some embankment would be removed and replaced with a channel to allow free flow of the river. Some channelization of the river in the dam reach would be necessary, as would be protection measures for the abandoned structures. The process of mothballing the project requires a number of tasks. One major task would be to provide facilities for passing adult fish upstream and juveniles downstream during construction activities, as well as during the time when the reservoir is being lowered.

5.3.4 Drawdown Alternative Comparisons

5.3.4.1 Spillway Crest Drawdown Summary

The fully-funded construction cost for the spillway crest drawdown was estimated at $1.033 billion dollars. The estimated implementation time is 10 years. In general, benefits identified by passage models for anadromous salmonids are predicted to be low, or near estimated survival ranges for current operation of the Lower Snake River Project. No benefits to adult salmonids are expected to result from spillway crest drawdown and, based on possible impacts of implementation, the potential exists for adverse effects. Power production, navigation, and the use of recreation facilities would be limited to near full-pool periods. Irrigation pumping plants would require major modifications in all drawdown scenarios.

Many unknowns exist in regards to the implementation process of this alternative because of the primary level of planning. The long-term in-water construction period would likely create significant adverse impacts to anadromous salmonids, as well as all environmental characteristics in the river and reservoir region. Lowering reservoir elevations during implementation and on an annual basis would presumably require modification to turbines for improved efficiency at these

elevations and interim elevation passage facilities for salmonids. These unknown effects and requirements could increase time and costs to achieve this alternative operation, therefore, worsening negative impacts.

Annual fluctuation of the river would cause perpetual erosion and water quality degradation, as well as a reduction in resident fish populations. The desiccation of shoreline vegetation would reduce terrestrial and aquatic wildlife in the lower Snake River region. Fluctuating reservoirs and associated erosion and exposure would uncover and damage multiple cultural resource sites.

The results of juvenile salmon reach survival studies for reservoirs and dams, conducted by NMFS on the lower Snake River in 1993 through 1996, coupled with results from studies regarding dam passage survival, indicate that reservoir mortality rates are relatively low in comparison to mortality rates associated with dam passage. In light of these results, it is now believed that spillway crest drawdowns, which eliminate only a third of the current reservoir length and still require passage of salmon through the dams, would be less biologically effective than previously thought. Additionally, the most significant problem, dam passage mortality, may be exacerbated rather than reduced.

The implementation and operation of spillway crest drawdowns would seasonally eliminate the operation of juvenile bypass and collection facilities, cause gatewell entrainment and injury, impair turbine efficiency (causing greater mortality), and eliminate the use of adult fish ladders. Major modifications of existing fish passage facilities and project operations would then be required in order to mitigate dam passage mortality. These modifications would significantly increase both the cost of spillway crest drawdowns and the implementation time.

No new biological information acquired since the NMFS 1995 Biological Opinion was issued in March 1995, in combination with the concerns mentioned above, indicates that there would be any value in pursuing further evaluations of the spillway crest drawdown alternative.

5.3.4.2 Natural River Annual Operation (Seasonal) Drawdown Summary

Seasonal near-natural river drawdown of the Lower Snake River Project would cost an estimated \$3.588 billion dollars to construct, and require up to 15 years to implement. Although benefits for anadromous salmonids were predicted by fish passage models to be substantially greater than with spillway crest drawdown, many unknowns still exist regarding engineering design and operation of the project during annual drafting of the reservoir and refill. Additionally, many unknowns exist in regards to the implementation process of this alternative because of the primary level of planning. The long-term in-water construction period would likely create significant adverse impacts to anadromous salmonids as well as all environmental characteristics in the river and reservoir region. Lowering reservoir elevations during implementation and on an annual basis would presumably require modification to turbines for improved efficiency at these elevations and would require interim elevation passage facilities for salmonids or would eliminate passage during drafting and refill. These unknown effects and requirements could increase time and costs to achieve this alternative operation, therefore, worsening negative impacts. Refill may require more than 3 months during low-flow years. Power production, navigation, and the use of recreation facilities would be limited to near-full-pool periods.

The annual fluctuation of the river would cause severe and perpetual erosion and water quality problems, as well as a reduction in resident fish populations. The desiccation and loss of shoreline vegetation in the drawdown zone would reduce terrestrial and aquatic wildlife in the lower Snake region. Fluctuating reservoirs and associated erosion and exposure would uncover and damage multiple cultural resource sites.

5.3.4.3 Natural River Year-Round (Permanent) Drawdown Summary

Construction cost to reach a permanent near-natural drawdown through the Lower Snake River Project was greatly reduced from the seasonal alternative, with an estimated fully-funded construction cost of $533 million. Implementation time was estimated at 5 years. Benefits for juvenile salmonids identified by fish passage models are anticipated to be the same or greater than the seasonal drawdown alternative. Risks associated with implementation are somewhat reduced by the shorter timeframe of 5 years. However, many unknowns exist in regards to the implementation process. The in-water construction period would likely create significant adverse impacts to anadromous salmonids as well as all environmental characteristics in the river and reservoir region. Initial lowering of the reservoir elevations could presumably require modification for interim passage facilities for salmonids or would eliminate passage during this period. Power production, navigation, and the use of currently developed recreation sites would be eliminated.

The initial drawdown of the reservoir to run-of-river elevation would cause severe erosion and water quality problems. The destruction of shoreline vegetation would initially reduce terrestrial and aquatic wildlife in the lower Snake region. Cultural resources sites would be exposed. However, with the river sustained at natural river elevation, pre-impoundment fish, wildlife, cultural, and recreation values would be regained. Cultural resource sites would be exposed at near-natural river elevations, but natural re-establishment of vegetation would stabilize the sites, protecting them from exposure, erosion, and possible vandalism.

5.3.4.4 Drawdown Conclusions

Seasonal spillway crest drawdown is recommended for removal from consideration, primarily because of its limited benefits for salmon, as identified by salmon passage model results. A spillway crest drawdown, instead of reducing the effects of dam passage, would likely intensify negative effects while at lower elevations and during drawdown and refill. In addition, extensive environmental impacts and cultural resource damage because of annual fluctuation, high implementation costs ($1.033 billion), and an extremely long implementation time make this alternative unattractive. Considering the current status of the salmon stocks, the long implementation time produces inappropriate risk.

Seasonal and permanent near-natural river drawdown alternatives are estimated by passage model results to provide improved survival for salmon. Seasonal near-natural river has a longer implementation time (15 years), recurring detrimental environmental impacts and cultural resource damage throughout the life of the project due to reservoir-to-river fluctuations, but also allows the ability to seasonally retain some power and navigation benefits. Project implementation costs were substantially higher ($3.588 billion) than spillway crest drawdown, and were more than six times the cost of permanent natural river drawdown construction.

Permanent near-natural river drawdown has the greatest estimated benefits for juvenile salmon in the lower Snake River, based on salmon passage model results, and elimination of reservoir and dam passage mortality once in operation. It would completely eliminate power production in the lower Snake River and commercial navigation between Lewiston, Idaho, and Pasco, Washington. These losses are counterbalanced by the lowest construction cost ($533 million) and the shortest implementation time (5 years). Cultural resource damage due to the uncovering of sites would be detrimental initially, but erosion caused by annual reservoir fluctuations would be greatly reduced and sites would eventually be protected by revegetation. Although other environmental impacts are initially substantial, maintaining a natural river would allow the ecosystem to achieve equilibrium in future years.

5.3.4.5 Recommendation

Based on estimated biological benefits, costs, other environmental effects, and regional acceptance; the permanent near-natural river option is the only drawdown alternative recommended for further study. For more details on the selection process refer to the Interim Status Report (Corps, 1996a).

5.4 Surface Bypass Collector System

The Walla Walla and Portland Districts of the Corps are evaluating surface bypass collector (SBC) systems as an alternative to drawdowns and other system improvements on the lower Snake and Columbia Rivers. The SBC concept stems from the successful implementation of a surface bypass system at Wells Dam on the Mid Columbia River [Public Utility District (PUD) Number 1, Douglas County, Washington]. The development of surface collection at Wells Dam began in the early 1980s, and took about 10 years of testing to reach its current form. Wells Dam has a relatively uncommon configuration, called a hydrocombine, in which the dam's spillway is located directly above the powerhouse, instead of side-by-side (as with all the other mainstem Columbia and Snake River dams). Fish are diverted through vertical slots located on the spillbays. More than 85 percent of all downstream migrants encountering Wells Dam are bypassed via this route. It has been hypothesized from this success that juvenile fish prefer to swim in the upper portion of the water column. Baseline studies at Lower Granite Dam support this hypothesis, indicating that 80 percent of the juvenile anadromous fish are located in the top 18 meters (60 feet) of the water column.

By 1994, the success at Wells Dam piqued regional interest in the notion that SBC systems might offer an alternative to the costly (and hard to maintain) turbine intake screens; large volumes of spill that contribute to high saturated gas levels in the tailrace and reduce flow available for power generation; and reservoir drawdowns, which have a tremendous economic impact. As a result of the recognized potential of the SBC concept, the Corps was called upon by NMFS, in Reasonable and Prudent Measure 11 in the 1995 Biological Opinion, to test a surface collector at Lower Granite Dam by June 1996. This measure was carried out on schedule.

As a prelude to the 1996 Lower Granite SBC evaluation, the Corps conducted a study of smolt passage into the Ice Harbor ice-and-trash sluiceway in 1995 (Biosonics, 1996). The ice-and-trash sluiceway was (it is no longer functional due to completion of a juvenile bypass system) a structure on the face of the Ice Harbor powerhouse that skimmed debris (and fish) off the surface

of the water. The openings to the sluiceway consisted of weir gates that allowed a few inches to a few feet of water to pass into a channel to the tailrace. Hydroacoustic studies in the 1980s documented that many (30 to 70 percent) of smolts passing the dam used the sluiceway. In 1995, vertical slots were attached to several of the weirs, and fish passage through the slots was compared to that over an unaltered weir. In 1995, it appeared that the surface-skimming weir passed more fish than either of the slot structures. Because of the limited hydraulic characteristics of the slots, however, it cannot be concluded that a similar weir would outperform a slot at Lower Granite Dam.

Prototype development was undertaken concurrently at several other key sites on the lower Snake and Columbia Rivers by the Corps (John Day Dam, The Dalles Dam and Bonneville Dam), and by Grant and Chelan County PUD's (Wanapum and Rocky Reach Dams, respectively). Data from all evaluations were shared among interested parties through workshops and brainstorming sessions. In addition, baseline data collection and secondary studies completed at lower Snake and Columbia River dams facilitated the implementation of SBC systems at those facilities, if justified by prototype test results.

5.4.1 Description of Prototype SBC Structure

The 1996 Lower Granite SBC prototype was intended to simulate the surface bypass configuration of Wells Dam. The SBC prototype is a floating steel structure located on the upstream face of powerhouse units 4 through 6 and spillbay 1. The floating structure is restrained by guides anchored to the powerhouse by rock anchor bolts. The SBC has an overall length of about 400 feet, maximum height of about 60 feet, and a maximum top width (at the top floatation components) of about 34 feet. The main channel section, across the powerhouse and angling toward the spillway, is connected to spillbay 1. Under normal project operations, the bottom of the structure is at approximately the same level as the top of turbine intakes 4, 5, and 6.

Fish and water enter the SBC channel through three fishway entrances on the upstream face of the structure. Each of the entrances consists of six pairs of air-operated gates that can be individually opened or closed. The pattern of open and closed entrance gates determines where fish can enter the SBC, and the volume and velocity of water flowing into the SBC. Once in the 20-foot-wide by 55-foot-deep channel, fish and water are drawn toward spillbay 1 (to the north). The fish and water pass under the spillbay 1 tainter gate, and over the spillbay to the tailrace.

The Corps evaluated the prototype SBC during late April through May 1996. The SBC was operated under three gate-opening configurations, and at two flow rates (2,100 and 3,900 cfs), which were varied on a daily basis. The entrance configurations were designed to simulate two conditions: 1) a deep vertical slot intended to simulate the Wells slot, and 2) a shallow slot intended to simulate a surface-oriented slot similar to one tested on the ice-and-trash sluiceway at Ice Harbor Dam in Spring 1995.

A detailed description of SBC structural features, and its operation, can be found in the Lower Granite Dam Surface Bypass and Collection System 1996 Prototype Test Operation Plan, dated May 20, 1996.

5.4.2 The 1996 through 2000 Evaluation Program, Results, and Coordination

The primary objectives of the 1996 SBC prototype test were threefold. First, could downstream-migrating juvenile salmon be enticed to enter an opening located above the powerhouse turbine intakes and safely pass to the tailrace via spillbay 1? This is the so-called proof of concept objective. Second, what type of entrance configuration and flow velocities worked best to entice fish to enter the SBC structure? Third, objectives 1 and 2 had to be accomplished without adversely affecting anadromous salmonid stocks passing the dam.

The prototype test plan was developed in coordination with Federal and state agencies and tribal representatives. Several research methods were used to evaluate the prototype evaluation objectives. The first evaluation was conducted to ensure that the SBC would safely pass fish. chinook salmon smolts obtained from a hatchery were tagged with small balloons and radio-tags. The balloon-tags inflate after a few minutes so the fish can be released into the water and recovered. Balloon-tagged fish were released into the SBC, into spillbay 2, and into the tailrace. The PIT-tagged steelhead smolts, which can be detected at downstream dams, were also released into the SBC.

Hydroacoustic equipment, which uses sonar to locate and count fish, was located at and around the SBC, as well as in turbine intakes in front of the powerhouse, and at the spillway. Mobile hydroacoustic equipment was also used to determine the depth distribution of fish in the forebay along transects. Water velocity in the forebay was measured along the same transects.

A complementary evaluation method to hydroacoustics was radio-telemetry. Yearling chinook salmon and steelhead smolts were implanted with radio-tags and released about 10 miles above Lower Granite Dam. The radio-tagged fish were tracked by boat to the dam, where dozens of aerial and underwater antennas monitored the movement and passage routes of the smolts. Northern squawfish were radio-tracked in the dam forebay and tailrace because of concern that these predatory fish might take advantage of the SBC structure or operations. Adult chinook salmon were also radio-tracked to determine whether these fish were affected by the SBC evaluation.

The 1996 SBC prototype test results were encouraging enough to garner regional support to proceed with continued prototype development at Lower Granite Dam. In order to facilitate a decision on the future configuration of the lower Snake River in 1999, plan development for prototype testing continued through 1999 with some final adjustments tested in 2000.

In spring 1997, the SBC was retested. During the 1996 test there were some entrance gates that did not work. These were repaired prior to the 1997 test. The floatation chambers were also removed from in front of the middle entrance so that it was open to the surface. A small trashboom was placed in front of the middle entrance to keep debris from entering the SBC. Results were similar to 1996. Approximately 40 percent of the fish, relative to units 4 through 6 where the SBC was located, entered and passed through the SBC.

A study was also conducted in the summer of 1997 to assess the performance of the SBC for subyearling (fall) chinook salmon. Radio-telemetry and hydroacoustics were used during the

summer evaluation, but it was later determined that the proliferation of non-target species during this time period made hydroacoustics not a viable monitoring technique.

Several major changes were made prior to the 1998 SBC evaluation. It was determined from the 1996 and 1997 evaluations that fish were being entrained into the turbine intakes before they had a chance to discover the SBC entrances. This was because the Lower Granite turbine intakes were designed to draw water from the entire depth of the forebay. By contrast, Wells Dam on the mid-Columbia River has turbine intakes that draw water from primarily the bottom of the reservoir. Because Wells has a successful surface bypass system, it was determined that if the Lower Granite intakes were to mimic those of Wells, the opportunity for fish to discover the SBC entrances would increase. An extension of the SBC, called the Simulated Wells Intake (SWI), was added to the bottom of the SBC, in effect increasing the depth of the SBC by about 20 feet and changing the hydraulic characteristics of the turbine intake. The second major addition to the SBC in 1998 was the Behavioral Guidance Structure (BGS). The BGS is a 1,100-foot steel "curtain" attached to the south end of the SBC, angling upstream towards the south shore of the forebay. The BGS was 80 feet high (deep) at it's connection to the SBC and about 55 feet deep at the upstream end, following the contours of the reservoir bottom. The BGS was intended to guide fish away from the south half of the powerhouse so they would pass through the SBC or spillway. A fourth entrance near the BGS connection was also added to the SBC in 1998.

The BGS proved successful in diverting nearly 80 percent of the fish originally bound for the south half of the powerhouse. The SWI was also successful, apparently reducing turbine entrainment and improving the performance of the SBC. As in 1998, a test in the summer with subyearling chinook showed a benefit to these fish both in increased fish passage efficiency and in a reduction in forebay delay for fish that passed through the SBC.

A regional decision was made in 1999 to not have an official test of the SBC that year. However, due to the success of the previous years, it was requested by NMFS and the state fishery agencies to operate the SBC and BGS for fish passage benefits during the spring migration. Fish passage was monitored with a minimal amount of hydroacoustic equipment.

The SBC was again tested in 2000. The entrance near the BGS was modified to provide for a more gradual water velocity acceleration, as this condition had shown in laboratory experiments to pass more fish than a "sharp-crested" weir or entrance. Two entrance configurations were tested in 2000, with only one or two of the four entrances being open at one time. SBC performance reached an all-time high in 2000 with the single entrance configuration. Detailed water flow measurements were also taken in 2000 that showed a flow through the SBC of just 3,500 cfs. It was previously thought that about 4,000 cfs were passing through the structure based on tainter gate opening and model results. Overall effectiveness (percentage of fish passed divided by percentage of water used) of the Lower Granite SBC approached that of Wells Dam in 2000.

If the SBC is used with the existing smolt transportation and bypass system at Lower Granite or other dams, the volume of water that passes into the SBC with the fish will have to be reduced. For example, the SBC at Lower Granite passed about 3,500 cfs. The current juvenile fish bypass and collection system uses about 250 cfs in the juvenile collection channel, which is "dewatered"

down to about 30 cfs before entering the juvenile fish separator. Obviously, a dewatering system with an order of magnitude larger than what currently exists at Lower Granite would have to be constructed in order to handle fish for collection and transportation that were collected with an SBC. This is not an insurmountable engineering hurdle, as a dewaterer with a capacity of around 6,000 cfs is soon to be constructed at Rocky Reach Dam on the mid-Columbia River. Most likely, a prototype dewatering system would have to be deployed and tested prior to implementation on an SBC system on any of the lower Snake River dams.

5.5 Alternatives to Carry Forward

In developing the Interim Status Report (Corps, 1996a), the Corps has examined and considered a number of sources of information. These include the SCS Phase I Report, the SOR EIS, the Salmon Decision Analysis Lower Snake River Feasibility Study, Final Report (Harza, 1996), Plan for Analyzing and Testing Hypotheses (PATH), and Return to the River (ISG, 1996), and biological data and engineering information gathered and developed during the last year.

Findings, based on consideration of all data, indicated there was insufficient information in 1996 (when the Interim Status Report was completed) for the Corps to make a recommendation on the best configuration of the hydropower system to reverse the decline of Snake River anadromous salmonid stocks in the lower Snake River. However, preliminary conclusions on the drawdown options indicated that spillway crest and natural river seasonal should be eliminated from further consideration. Consequently, the Corps recommended continued investigation of three courses of action to improve salmon migration, including permanent drawdown to natural river, surface bypass collection, and the current operational fish programs, as well as combinations of the three.

6. SCS Phase II – Feasibility Study

Three Pathways were identified in the Interim Status Report (Corps, 1996a) for further study during the Feasibility Study part of SCS Phase II. The three Pathways are Existing Systems, Major System Improvements, and Natural River Drawdown.

The Existing Systems is the "Base Case" or "Future Without Project Condition." It is the alternative against which all other proposed alternatives are evaluated. However, it is not a stationary alternative because there are constant improvements being made to existing facilities and structures that allow it to be the most beneficial for passage. Several options were considered under the Existing Systems framework.

The Major System Improvements Pathway was not investigated in great detail in either SCS Phase I or the Interim Status Report. The Feasibility Study phase has considered a number of options, evaluating each and selecting the one that held the greatest promise for success. This pathway focuses on major structural changes at the dams, which are designed to attract fish under conditions more conducive to their behavior and bypass.

The Natural River Drawdown Pathway was refined down to one option for further study. The Interim Status Report recommended the permanent drawdown to near-natural river.

6.1 Fish Passage Strategies

The Feasibility Study considered three fish passage strategies in order to define and evaluate the various alternatives. The strategies include:

- In-River Passage – Keeping the fish in the river during their downstream migration
- Transport – Collecting and transporting the fish downstream of Bonneville Dam
- Spread-the-risk – Distributing the passage of fish somewhat equally between in-river and transport
- Adaptive Migration – Providing operational alternatives to allow an effective method for either in-river passage or transport.

These strategies were applied to the options for upgrading the existing facilities and to Major System Improvements alternatives. The modifications required for upgrading the Existing System include the following:

- Improvement of the effectiveness of the juvenile fish bypass and collection facilities
- Additional barges for fish transportation
- Turbine modifications and improvements made during a major rehabilitation of the powerhouse
- Modification of spillways to reduce dissolved gas levels.

Major System Improvements options include:

- upgrading the existing system
- constructing surface bypass and collection systems
- constructing removable spillway wier
- adding new extended submerged bar screen in turbine entrances.

SBC systems consists of surface collectors, BGS, and modified spillbays.

Tables 6-1 and 6-2 summarize the measures identified within each alternative considered as part of the Feasibility Study. Table 6-1 focuses on the existing system operations and those major elements of the operation. Table 6-2 introduces a series of upgrades as well as major system improvements measures.

6.2 Existing Systems Pathway and Potential Upgrades

Features of the Existing Systems and its operations are described in Appendix E, Existing Systems and Major Systems Improvements Engineering.

The Existing Systems Pathway consists of continuing present fish passage facilities and operations that were in place or under development at the time the Feasibility Study was initiated. However, some Existing Systems upgrades are proposed to present systems in order to bring the existing facilities to state-of-the-art designs and operations. Depending upon the alternative being evaluated, ongoing improvements would include such things as modified turbine intake screens, additional fish transport barges, additional end bay flow deflectors on spillways, turbine modifications, and others.

Upgrades considered to the existing system vary somewhat depending upon the assumed method of aiding fish migration (i.e., whether the fish are transported or bypassed). The following three options define the Existing Systems Upgrade alternative, which is the "base case" or "future without project" against other alternatives are evaluated.

6.2.1 In-River Passage with Voluntary Spill Options (A-1a)

This option assumes the juvenile fishway systems will be operated to maximize in-river fish passage. It also assumes voluntary spill will be used to bypass fish through the spillways.

6.2.1.1 Dissolved Gas Abatement Measures

Because fish would remain in the river and voluntary spill would be used to attract fish to the spillway, it is important to implement dissolved gas abatement improvements. These measures include:

- Spillway monitoring for all dams would be continued
- Two end-bay deflectors would be added at Lower Monumental and Little Goose Dams
- The existing deflectors at Lower Monumental, Little Goose, and Lower Granite Dams would be modified.

Table 6-1. Existing System Operations Measures

	Existing Systems Pathway			Major System Improvements Pathway						Natural River Drawdown Pathway	
	A-1	A-1a	A-2a	A-2b	A-2c	A-2d	A-6a	A-6b	A-6d	A-3a	A-3b
Existing System Operations[1/]	**Existing Condition**	**In-River Passage**	**Maximum Transport**	**Maximum Transport (High Cost)**	**Maximum Transport (Low Cost)**	**Adaptive Migration**	**In-River Passage (Added Flow Augmentation)**	**In-River Passage (No Flow Augmentation)**	**Alternate In-River**	**Dam Breaching**	**Dam Removal**
Adult Fish Passage Systems											
Fish Ladders	x	x	x	x	x	x	x	x	x		
Pumped Attraction Water Supplies	x	x	x	x	x	x	x	x	x		
Powerhouse Fish Collection Systems	x	x	x	x	x	x	x	x	x		
Juvenile Fish Bypass and Collection Systems											
STS – Ice Harbor and Lower Monumental	x	x	x	x	x	x	x	x	x		
ESBS – Little Goose and Lower Granite	x	x	x	x	x	x	x	x	x		
Collection and Transportation Facilities	x	x	x	x	x	x	x	x	x		
Trash Shear Boom	x	x	x	x	x	x	x	x	x		
Minimum Operating Pool - During Fish Outmigration	x	x	x			x					
Turbine Operations - Within 1 percent Peak Efficiency	x	x	x	x	x	x	x	x	x		
Voluntary Spill											
Current Operations	x	x					x	x			
Minimize Operations			**x (Ice Harbor Only)**		**x (Ice Harbor Only)**				**x (Little Goose Only)**		
Optimize Operations						x					
No Spill				x						x	x
Flow Augmentation (Dworshak)	x	x	x	x	x	x	x	x	x	x	x
Flow Augmentation (Upper Snake River)											
Zero Flow Augmentation								x			
427,000 acre-feet	x	x	x	x	x	x			x	x	x
1,427,000 acre-feet							x				
Dissolved Gas Abatement Measures											
Spillway Gas Control Measures (Deflectors)	x	x	x	x	x	x	x	x	x		
Spillway Gas Monitoring	x	x	x	x	x	x	x	x	x		
Continue Fish Facility Operations	x	x	x	x	x	x	x	x	x		
Continue AFEP Evaluations	x	x	x	x	x	x	x	x	x		
Power											
Current Production	x	x		x	x	x	x	x	x		
Increased Production			x								
No Production										x	x
Navigation											
Current Operations	x	x	x	x	x	x	x	x	x		
No Operations										x	x
Fish Transportation											
Spread-the-Risk	x										
Optimize Transportation						x					
Maximize Transportation			x	x	x						
No Transportation		x					x	x	x	x	x
Lower Snake River Fish and Wildlife Compensation Plan											
Current Wildlife Habitat Operations	x	x	x	x	x	x	x	x	x	**x (20-30 yr period)**	**x (20-30 yr period)**
Hatchery Program to Include Captive Broodstock	x	x	x	x	x	x	x	x	x	x	x
Recreation Requirements											
Current Operations	x	x	x	x	x	x	x	x	x		
Amended Operations										x	x

Table 6-2. Existing Systems Upgrades and Major System Improvements Measures

	Existing Systems Pathway			Major System Improvements Pathway						Natural River Drawdown Pathway	
	A-1	A-1a	A-2a	A-2b	A-2c	A-2d	A-6a	A-6b	A-6d	A-3a	A-3b
	Adaptive Migration	In-River Passage	Maximum Transport	Maximum Transport (High Cost)	Maximum Transport (Low Cost)	Adaptive Migration	In-River Passage (Added Flow Augmentation)	In-River Passage (No Flow Augmentation)	Alternate In-River	Dam Breaching	Dam Removal
Existing System Upgrades											
Dissolved Gas Abatement Measures											
Add End-Bay Deflectors/Pier Extensions – Lower Monumental and Little Goose	x	x	x	x	x	x	x	x	x		
Modify Existing Deflectors – Lower Monumental, Little Goose, and Lower Granite	x	x				x	x	x	x (Little Goose Only)		
Turbine Measures	x										
Install Turbine Minimum Gap Runners	x	x	x	x	x	x	x	x	x		
Miscellaneous Measures											
Upgrade Adult Fish Passage Systems	x	x	x	x	x	x	x	x	x		
Upgrade Lower Granite Juvenile Fish Facility											
Limited Modifications		x					x	x	x		
Extensive Modifications	x		x	x	x	x					
New Cylindrical Dewatering Screens	x	x	x	x	x	x	x	x	x		
Modify ESBS at Little Goose and Lower Granite	x	x	x	x	x	x	x	x	x		
Additional Barges/Mooring Facilities	x		x	x	x	x					
New Wet Separators at Lower Monumental, Little Goose, and Lower Granite	x		x	x	x	x					
Major System Improvements											
Ice Harbor Dam											
Full-Length Powerhouse Channel w/o Dewatering							x	x			
One Removable Spillbay Wier w/ BGS									x		
Two RSWs w/ BGS						x					
Replace STSs with ESBSs				x	x	x	x	x	x		
Lower Monumental Dam											
Full-Length Powerhouse Channel w/o Dewatering							x	x			
Full-Length Powerhouse Channel w/ Dewatering				x							
Two-Unit Powerhouse Channel w/ Dewatering						x					
One Removable Spillbay Wier w/ BGS									x		
Two RSWs w/ BGS						x					
Replace STSs with ESBSs				x	x	x	x	x	x		
Little Goose Dam											
Full-Length Powerhouse Channel w/o Dewatering							x	x	x		
Full-Length Powerhouse Channel w/ Dewatering				x							
Full-Length Powerhouse Occulsion						x					
One Removable Spillbay Wier w/ BGS											
Two RSWs						x					
Lower Granite Dam											
Full-Length Powerhouse Channel w/o Dewatering							x	x			
Full-Length Powerhouse Channel w/ Dewatering				x	x						
Two-Unit Powerhouse Channel w/ Dewatering						x					
One Removable Spillbay Wier w/ BGS									x		
Two RSWs w/ BGS						x					

6.2.1.2 Turbine Measures

Because of the tremendous costs of implementing major changes to the turbines, it is assumed improvements to the turbines to improve fish passage will be incorporated in the scheduled turbine rehabilitation for each dam. The exact nature of turbine improvements has yet to be determined. For the purposes of the Feasibility Study, a minimum gap runner design was installed in each turbine.

6.2.1.3 Miscellaneous Measures

Unless specifically identified, the existing features, improvements to existing features, and new features that are listed below would apply to all four lower Snake River dams:

- Existing adult fish passage systems with upgraded adult fish passage modifications
- Existing juvenile fish bypass and collection systems with upgrades to the Lower Granite Juvenile Fish Facilities (less separator, raceway, distribution flume, and direct barge loading upgrades at Lower Granite Dam)
- MOP with 527 million cubic meters (427 thousand acre-feet [KAF]) flow augmentation from upstream storage in Idaho
- New cylindrical dewatering screens
- Modification of existing ESBSs at Little Goose and Lower Granite
- Operation of fish hatcheries
- Continuation AFEP evaluations.

6.2.2 Maximum Transport Option (A-2a)

This option assumes the juvenile fishway systems would be operated to maximize fish transportation. Fish would be bypassed at Ice Harbor; therefore, spill is still included for Ice Harbor only.

6.2.2.1 Dissolved Gas Abatement Measures

Because most fish would be transported, and voluntary spill is used only at Ice Harbor Dam, it is not necessary to modify existing deflectors at Lower Granite, Little Goose, and Lower Monumental. However, additional end-bay deflectors at Lower Monumental and Little Goose Dams are still included to benefit upstream adult passage under any spill condition, as is spillway monitoring.

6.2.2.2 Turbine Measures

This is the same as In-river Passage with Spill Option.

6.2.2.3 Miscellaneous Measures

The same list of measures identified in the In-river Passage with Spill Option is included here, plus the following:

- New barges
- New separators at Lower Granite, Little Goose, and Lower Monumental Dams
- The existing juvenile fish facility at Lower Granite Dam would have more extensive modifications to improve juvenile fish transportation operations.

6.2.3 Spread-the-Risk (A-1)

This option assumes the juvenile fishway systems will be operated in a manner that will balance the passage of fish between in-river and transport methods. This is the current operational strategy for the lower Snake River dams per NMFS 1995 and 1998 Biological Opinions. Voluntary spill will still be used to bypass more fish through the spillways. This is the current operating strategy for the Lower Snake River Project.

6.2.3.1 Dissolved Gas Abatement Measures

Dissolved gas abatement measures include bypassing some of the fish over the spillway and utilizing voluntary spill approaching the gas cap to attract fish to the spillway. Measures are similar to In-river Passage with Spill Option.

6.2.3.2 Turbine Measures

This is the same as In-river Passage with Spill Option.

6.2.3.3 Miscellaneous Measures

The same list of measures identified in the In-River Passage with Spill Option is included here, plus the following:

- New barges
- New separators of Lower Granite, Little Goose, and Lower Monumental Dams
- The existing juvenile fish facility at Lower Granite Dam would have more extensive modifications to improve juvenile fish transportation operations.

6.2.4 Recommended Existing Systems Upgrade Option

Two of the three options described as Existing Systems Upgrades have been carried forward into the Feasibility Study. The Spread-the-Risk and the Maximum Transport options have a higher fish survival through the system. The Maximum Transport option shows that approximately 93 percent of the fish transported survive to below Bonneville and the Adaptive Management Strategy shows that approximately 83 percent of the fish survive to below Bonneville. The In-river option only shows that approximately 55 percent of the fish make it to below Bonneville. In-river migration of fish through a reservoir is significantly less successful. See Table 6-3.

Table 6-3. Existing System Upgrades Options

Options		Fish Survival Through the System
Number	**Description**	**(%)**
A-1	Spread-the-Risk	83.38
A-1a	In-river Passage	54.94
A-2a	Maximum Transport	93.11

6.3 Major System Improvements

Major System Improvements consist of measures beyond those previously mentioned as Existing System Upgrades that have a high potential of increasing the effectiveness and efficiency of juvenile fish passage around the dams. Each Major System Improvements option would include various Existing System upgrade options to provide an improved overall strategy for aiding downstream fish passage. Greater detail for each option identified below can be found in Appendix E, Existing Systems and Major System Improvements Engineering.

6.3.1 In-River Passage with Higher Flow Augmentation Option (A-6a)

This option assumes the juvenile fishway systems will be operated to maximize in-river fish passage. This option also includes 1.427 million acre-feet (MAF) of flow augmentation from upstream storage. Voluntary spill would be used at each dam to attract fish away from the powerhouse towards the spillway.

6.3.1.1 Existing Systems Upgrades

All Existing Systems upgrade measures identified with the Existing Systems Upgrades In-River Option except for flow augmentation, which is increased in this option as described above.

6.3.1.2 Major System Improvements

The migration strategy is to focus on effective diversion of fish away from the turbines for in-river migration. All four dams would be outfitted with a full-length powerhouse SBC (six-unit bypass) channel without de-watering screens. Fish would pass directly downstream to the tailrace through modified spill flow. ESBS intake diversion systems would be used to maximize effective diversion from turbines to divert fish that might pass under the channels. Fish diverted by the ESBS systems would continue to be directed to the juvenile fish facilities where these fish could be delivered directly into the tailrace.

The existing ESBS systems at Little Goose and Lower Granite would be upgraded. The STS systems at Ice Harbor and Lower Monumental would be replaced with ESBS systems.

6.3.2 In-river Passage with No Flow Augmentation Option (A-6b)

Same as In-river Passage with Flow Augmentation Option except there would be no flow augmentation. Voluntary spill, Existing Systems Upgrades, and SBC migration strategy would be the same.

6.3.3 Alternate In-river Option (A-6d)

This option assumes the juvenile fishway systems will be operated to maximize in-river fish passage. Includes 427 KAF of flow augmentation from upstream storage. Voluntary spill would occur only at Little Goose.

6.3.3.1 Existing Systems Upgrades

Most Existing Systems upgrade measures identified with the Existing Systems Upgrades In-river Option are included here. The differences that exist are due to no voluntary spill at Ice Harbor, Lower Monumental, and Lower Granite. Little Goose will have the existing deflectors modified for dissolved gas abatement improvements, while the other three will have no such improvements.

6.3.3.2 Major System Improvements

The migration strategy is to focus on effective diversion of fish away from the turbines for in-river migration. For this combination, Ice Harbor, Lower Monumental, and Lower Granite incorporate RSWs. A RSW would be placed on the spillbay adjacent to the powerhouse to provide more fish-friendly bypass over the spillway. A BGS would extend upstream from the interface of the powerhouse and spillway. There would be no need for voluntary spill because the BGS is expected to divert about 78 percent of the fish away from the powerhouse towards the spillway.

At Little Goose, a full length powerhouse SBC channel would be used without a dewatering device. Fish would be collected in the SBC, guided to the spillbay adjacent to the powerhouse, and passed over a raised spillway, downstream to the tailrace. Voluntary spill would be used to increase the percentage of fish passed over the spillway.

The existing ESBS intake system at Little Goose and Lower Granite would be used to divert fish that pass under the channel and into turbine intakes. Fish diverted by the ESBS systems would continue to be directed to the juvenile fish facilities where they would be delivered to the tailrace. A new ESBS system would be installed in the turbine intakes at Ice Harbor and Lower Monumental to replace the existing STS system.

6.3.4 Maximized Transport System (High Cost) Option (A-2b)

This option assumes juvenile fishway systems will be operated to maximize fish transport and that voluntary spill will not be needed. This includes 427 KAF of flow augmentation from upstream storage.

6.3.4.1 Existing Systems Upgrades

All Existing Systems upgrade measures identified with the Existing Systems Upgrades Maximum Transport Option except there would be no voluntary spill at any of the four dams.

6.3.4.2 Major System Improvements

The migration strategy is to maximize the number of fish collected and delivered to the transportation facilities located at Lower Monumental, Little Goose, and Lower Granite Dams.

At Ice Harbor Dam fish will be bypassed. Fish collection would be accomplished by constructing a full-length powerhouse SBC channel with dewatering screens to concentrate fish for delivery to the transportation facilities and either trucked or barged downstream to below Bonneville Dam. The number of fish migrating in-river would be minimized and drop significantly at each consecutive dam.

The existing ESBS intake system at Little Goose and Lower Granite would be used to divert fish that pass under the channel and into turbine intakes. Fish diverted by the ESBS systems would continue to be directed to the juvenile fish facilities where they would be available for transport. A new ESBS system would be installed in the turbine intakes at Ice Harbor and Lower Monumental to replace the existing STS system.

6.3.5 Maximized Transport System (Low Cost) Option (A-2c)

This option assumes juvenile fishway systems will be operated to maximize fish transport and that voluntary spill will needed at Ice Harbor only. This also includes 427 KAF of flow augmentation from upstream storage.

6.3.5.1 Existing Systems Upgrades

All Existing Systems upgrade measures identified with the Existing Systems Upgrades Maximum Transport Option.

6.3.5.2 Major System Improvements

The migration strategy is to maximize the number of fish collected and delivered to the transportation facilities located at Lower Granite Dam only. At Ice Harbor, Lower Monumental, and Little Goose Dams fish will be bypassed. Fish collection would be accomplished by constructing a full-length powerhouse SBC channel with dewatering screens to concentrate fish for delivery to the transportation facilities and either trucked or barged downstream to below Bonneville Dam. The number of fish migrating in-river would be minimized and would drop significantly at each consecutive dam.

The existing ESBS intake system at Little Goose and Lower Granite would be used to divert fish that pass under the channel and into turbine intakes. Fish diverted by the ESBS systems would continue to be directed to the juvenile fish facilities where they would be available for transport. A new ESBS system would be installed in the turbine intakes at Ice Harbor and Lower Monumental to replace the existing STS system.

6.3.6 Adaptive Migration Strategy Option (A-2d)

This option assumes juvenile fishway systems will be operated in a manner that will balance the passage of fish between in-river and transport fish passage methods. The Adaptive Migration Strategy would optimize current operational objectives where either in-river or transport strategies can be used. This strategy addresses concerns about risks and effectiveness associated with bypass-only and transport-only. This option allows for flexibility in operational changes within a migration season. This also includes 427 KAF of flow augmentation from upstream storage.

6.3.6.1 Existing System Upgrades

All Existing Systems upgrade measures identified with the Existing System Upgrades Spread-the-Risk Strategy (A-1).

6.3.6.2 Major System Improvements

The adaptive migration strategy allows for either optimizing transportation or in-river migration. At Lower Monumental and Lower Granite Dams, a two-unit powerhouse SBC channel with dewatering screens would be installed. Fish collected would be channeled to the fish collection facility and transported. A BGS would be installed to direct fish away from the four units without collectors. When it is desired to keep the fish in the river, the SBC would be shut off and the fish would be guided by the BGS to the two RSWs. The RSWs would provide a surface attraction flow, allowing for spilling of fish over the spillway with less stress involved than normal spillway passage.

ESBS intake diversion systems would be upgraded at Lower Granite and the STSs at Lower Monumental would be replaced with ESBSs. Fish that pass around or under the BGS would be bypassed using this system.

At Little Goose, a full-length powerhouse SBC occlusion structure will be installed to improve the performance of the ESBS and to increase guidance of fish away from the turbine intakes and towards the spillway. In addition, two RSWs would be installed. The existing ESBSs would be upgraded. The ESBSs would direct fish to a point of collection or return the fish to the river.

Ice Harbor would only have two RSWs with the BGS installed. The current STSs would be replaced with new ESBSs. The Ice Harbor facility would continue to bypass fish with no intent to collect.

6.3.6.3 Voluntary Spill

When operating in bypass mode, it is anticipated that there would be a need for voluntary spill only over the RSWs at Lower Granite, Lower Monumental and Ice Harbor Dams. This is because the BGS proposed for these dams is expected to divert about 78 percent of the fish away from the powerhouse towards the RSWs. Two RSWs are also expected to provide adequate surface attraction to the spillways at these dams. Full scale testing would be required to verify surface attraction.

Model testing is required to determine the ability of the Occlusion Structure to effectively divert fish to the spillway RSWs at Little Goose. Then, the need for additional voluntary spill at Little Goose can be accessed. This would apply when the river is in bypass or transport mode.

When transporting fish, there would be no need for voluntary spill at Lower Granite or Lower Monumental Dams because the fish would be collected for transport. Voluntary spill over the RSWs alone is required at Little Goose and Ice Harbor in an effort to bypass fish at these dams.

6.3.7 Recommended Major System Improvement Option

The In-river Fish Passage Strategy with a reservoir has notably less fish survival than the Transport and Adaptive Migration strategies (Table 6-4). Because of this and the concern over delayed mortality, the NMFS continues to support a sharing of risk between in-river passage and fish transportation. The Adaptive Migration option combines the two strategies while incorporating some flexibility to allow for increased use of one passage method over the other when flow conditions support one over the other. For these reasons, the only option selected to represent the Major Systems Improvement Pathway in the final Feasibility Study analysis is the Adaptive Migration option.

Table 6-4. Major System Improvements Options

Options		Fish Survival Through the System
Number	**Description**	**(%)**
A-2b	Maximum Transport (High Cost)	95.45
A-2c	Maximum Transport (Low Cost)	95.41
A-2d	Adaptive Migration	**See Note**
A-6a	In-River Passage (Added Flow Augmentation)	65.87
A-6b	In-River Passage (No Flow Augmentation)	no data available
A-6d	Alternate In-River	no data available

Note: Fish survival with surface bypass collection (SBC) has been modeled to be 89.08 percent. This does not include the RSW which will be prototype tested. Therefore, no percent survival is given here. However, preliminary modeling conducted by NMFS indicates the RSW to have good potential for success and it is anticipated that when combined with existing SBC technology it will improve upon that identified for the SBC alone.

7. Feasibility Study Alternatives

The SCS study began as an analysis of not only the lower Snake River, but also lower Columbia River facilities. The Salmon Summit along with other regional activities, helped to shape the initial set of alternatives considered in the SCS. As the SCS progressed from reconnaissance level of study to feasibility level of study, the implementation of the NMFS 1995 Biological Opinion further influenced alternative selection and analysis. The SCS moved into the Feasibility Study considering actions only on the lower Snake River hydrosystem, with those measures identified for the lower Columbia River system to be considered under other study efforts. For this section, only the alternatives studied in detail for the Lower Snake River Project will be discussed and summarized.

7.1 Alternatives Analysis

A series of alternatives have been considered during the planning process as discussed in the previous chapters. Through the use of established screening criteria, various alternatives were dropped from further consideration. These screening measures included: Technical Feasibility, Biological Effectiveness, Other Significant Environmental Effects, Cost Effectiveness, and Regional Acceptability. Table 7-1 displays alternatives considered by the Corps from the initiation of the SCS process through its completion. It also identifies the rationale for not considering certain alternatives further in the study process.

Four alternatives have been carried forward through the entire study process with the intent to identify a preferred alternative from the four alternatives advanced. These four alternatives are:

- Alternative 1—Existing Conditions – This alternative is the base case, "no action" or the "future without major project changes" against which other alternatives are evaluated. It consists of the continued operation of the fish passage facilities that were in place or under development at the time this Feasibility Study was initiated. Table 7-2 identifies activities associated with the Existing Conditions alternative. It also includes a series of upgrades to existing systems. The Spread-the-Risk strategy would be utilized for this alternative.
- Alternative 2—Maximum Transport of Juvenile Salmon– This alternative includes all activities of Existing Conditions, except it assumes that the juvenile fishway systems would be operated to maximize fish transport and that voluntary spill would be not be used to bypass fish through the spillways (except at Ice Harbor). Table 7-2 identifies activities associated with the Maximum Transport of Juvenile Salmon Alternative. Also included are a series of upgrades to existing systems.
- Alternative 3—Major System Improvements – This alternative is also known as Adaptive Migration. This alternative includes all activities of Existing Conditions, except it assumes that the juvenile fishway systems would be operated to optimize voluntary spill and fish transportation through a series of operating rules established within the region. A new set of operating rules would also be established within the region to better utilize Dworshak flow augmentation for the passage of juvenile salmonids. Table 7-2 identifies activities associated with the Major System Improvements Alternative. This table also identifies a series of existing system upgrades and major system improvement actions that make up this alternative.

- Alternative 4—Dam Breaching – Structural modifications would be undertaken at the dams allowing reservoirs to be drained, resulting in a near-natural river that would remain unimpounded yet controlled. Flow augmentation from Dworshak and the upper Snake River is assumed to continue. There would no longer be any power production or navigation for commodity transport on the lower Snake River. Table 7-1 identifies activities associated with the Dam Breaching Alternative.

7.2 Resource Effects Analysis

A resource effects analysis was conducted, by reviewing the impacts of each of the four alternatives carried forward against a series of resources associated with the Lower Snake River Project. The direct, indirect, and cumulative effects were considered for each resource area. Evaluating the cumulative effect of each set of actions proposed on the resources compared to reasonably foreseeable sets of actions by other entities in the region has been the greatest challenge. All of the four alternative actions considered under this study would promote the increased survival of juvenile salmon through the Lower Snake River Project; however, they all may not assist in the recovery of listed salmon and steelhead stocks. This is because many other actions or activities involving other resource areas in the region likely do not aid in the recovery of the stocks rather than increase resources.

Annex A presents a series of tables that compare the following resource areas against the four alternatives:

- Geology and Soils
- Air Quality
- Water Resources: Temperature
- Water Resources: Dissolved Gas
- Water Resources: Sedimentation
- Water Resources: Contaminants
- Aquatic Resources: Spring/Summer Chinook
- Aquatic Resources: Fall Chinook
- Aquatic Resources: Steelhead
- Aquatic Resources: Other A-Fish
- Aquatic Resources: Resident Fish
- Terrestrial Resources: Vegetation
- Terrestrial Resources: Wildlife
- Terrestrial Resources: ESA Plant Species
- Terrestrial Resources: ESA Wildlife Species
- Cultural Resources
- Native American Indians
- Social Resources: Community Assessments
- Social Resources: Low Income/Minority Populations
- Land Ownership and Use
- Aesthetics
- Economics: National Economic Development
- Economics: Passive Use Value

Issues due to uncertainties surrounding available information or lack of available information have been identified for those resource areas to which they relate.

7.3 Resource Uncertainty

Uncertainty is inherent in any planning effort, especially when the period of analysis spans 100 years as in this study. Many of the potential biological, economic, and social effects of the alternatives are not known with certainty for several reasons. Information might be lacking, incomplete, or unreliable or could reflect natural variability in the resource studied. There are also uncertainties in the assumptions and models used to extrapolate this information to future conditions. Uncertainties in environmental effects of alternatives are identified, described, and quantified when possible. The relative importance of uncertainties will depend on how they influence efforts to compare the potential benefits and costs of the alternative actions.

Annex B presents the effects of each alternative to those resource areas previously identified. Where possible, the effect has been quantified. However, quantification is not extensive across resource areas due to the lack of detailed information for such presentation. The other challenge when comparing effects of resources is that few of the resources can be measured using the same type of metrics, making comparisons between resource areas difficult. An attempt to capture uncertainty for each resource area has been made. This determination of uncertainty is a reflection of the quality of the information available for consideration or the reliability of the methodology used for quantifying the information available.

Table 7-1. Alternative Screening

PATH #	Corps #	Alternative Description
Lower Snake River Drawdown Options – SCS Phase I		
		Variable Pool – No Power House Operation
	1	Existing Spillway Only
Eliminated by initial screening during SCS Phase I. Not feasible due to adverse impact on adult fish passage, associated high dissolved gas levels, and problems associated with passing juvenile fish juvenile fish over the spillways.		
	2	Modified Spillway Only
Eliminated by initial screening during SCS Phase I. Not feasible due to adverse impact on adult fish passage, associated high dissolved gas levels, and problems associated with passing juvenile fish juvenile fish over the spillways.		
	3	New Low-Level Spillway Only
Eliminated by initial screening during SCS Phase I. Not feasible due to adverse impact on adult fish passage, associated high dissolved gas levels, and problems associated with passing juvenile fish juvenile fish over the spillways.		
	4	Auxiliary Regulation Outlet (ARO) Only
Eliminated by initial screening during SCS Phase I. Not feasible due to the risk to adult fish passage.		
	4A	Natural River Option
Carried forward into Feasibility Study		
		Variable Pool with Existing Powerhouse
	5	Existing Powerhouse with Existing Spillway
Eliminated during SCS Phase I evaluation because modeling indicated limited benefits to anadromous fish.		
	6	Existing Powerhouse with Modified Existing Spillway
Eliminated by initial screening during SCS Phase I due to unacceptable impacts to turbines and unacceptable operational impacts to fish bypass system components.		
	7	Existing Powerhouse with New Low-Level Spillway
Eliminated by initial screening during SCS Phase I due to unacceptable impacts to turbines and unacceptable operational impacts to fish bypass system components.		
	8	Existing Powerhouse with ARO
Eliminated by initial screening during SCS Phase I because not feasible due to the risk to adult fish passage		
		Variable Pool with Modified Powerhouse
	9	Modified Powerhouse with Existing Spillway
Eliminated during SCS Phase I evaluation because modeling indicated limited benefits to anadromous fish.		
	10	Modified Powerhouse with Modified Existing Spillway
Eliminated by initial screening during SCS Phase I due to unacceptable impacts to turbines and unacceptable operational impacts to fish bypass system components.		
	11	Modified Powerhouse with New Low-Level Spillway
Eliminated by initial screening during SCS Phase I due to unacceptable impacts to turbines and unacceptable operational impacts to fish bypass system components.		
	12	Modified Powerhouse with ARO
Eliminated by initial screening during SCS Phase I because not feasible due to the risk to adult fish passage		

Table 7-1. Alternative Screening

PATH #	Corps #	Alternative Description
		Constant Pool with Existing Powerhouse
	13	Modified Powerhouse with Existing Spillway
Eliminated during SCS Phase I evaluation because modeling indicated limited benefits to anadromous fish.		
	13A	Modified Powerhouse with Existing Spillway – LGR Only
Eliminated during SCS Phase I evaluation because modeling indicated limited benefits to anadromous fish, although some marginal benefits were seen for spillway crest.		
	14	Modified Powerhouse with Modified Existing Spillway
Eliminated during SCS Phase I evaluation because modeling indicated limited benefits to anadromous fish.		
	15	Modified Powerhouse with New Low-Level Spillway
Eliminated during SCS Phase I evaluation because modeling indicated limited benefits to anadromous fish.		
	16	Modified Powerhouse with ARO
Eliminated by initial screening during SCS Phase I because not feasible due to the risk to adult fish passage.		
		Constant Pool with Modified Powerhouse
	17	Modified Powerhouse with Existing Spillway
Eliminated during SCS Phase I evaluation because modeling indicated limited benefits to anadromous fish.		
	18	Modified Powerhouse with Existing Spillway
Eliminated during SCS Phase I evaluation because modeling indicated limited benefits to anadromous fish.		
	19	Modified Powerhouse with New Low-Level Spillway
Eliminated during SCS Phase I evaluation because modeling indicated limited benefits to anadromous fish.		
	20	Modified Powerhouse with ARO
Eliminated by initial screening during SCS Phase I because not feasible due to the risk to adult fish passage.		
Lower Snake River Drawdown Options – SCS Phase II: Interim Status Report		
		Spillway Crest Drawdown
Eliminated during SCS Phase II evaluation because modeling identified limited benefits for salmon.		
		Natural River Annual Operation (Seasonal) Drawdown
Eliminated during the SCS Phase II evaluation because of the long implementation time, the recurring detrimental environmental and cultural impacts, and high implementation costs.		
		Natural River Year-Round (Permanent) Drawdown
Evaluated as Alternative 4 in the Feasibility Study.		
Upstream Collection and Conveyance – SCS PHASE I		
		Migratory Pipeline
Eliminated during SCS Phase I evaluation because of significant biological and uncertainty concerns.		
		Pressure Pipeline
Eliminated during SCS Phase I evaluation because of significant biological and uncertainty concerns.		

Table 7-1. Alternative Screening

PATH #	Corps #	Alternative Description
		Pressure Pipeline
Eliminated during SCS Phase I evaluation because of significant biological and uncertainty concerns.		
		Barge Transportation
Carried forward into Feasibility Study		
		Floating Pipeline
Eliminated during SCS Phase I evaluation because of significant biological and uncertainty concerns.		
Existing System Pathway – SCS Phase II		
	A-1a	In-River Passage
Eliminated during SCS Phase II since PIT Tag data showed in-river passage with reservoirs in place was less beneficial than transportation of juvenile salmonids below Bonneville.		
A-2	A-2a	Maximum Transport
Evaluated as Alternative 2 in the Feasibility Study.		
Major System Improvements Pathway – SCS Phase II		
A-2'	A-2b, A-2c	Maximum Transport – High Cost (A-2b) and Low Cost (A-2c)
Eliminated during SCS Phase II. NMFS believed the Corps could collect up to 85 % of the fish migrating in any given season, therefore refinements would do little to advance survival. In addition, maximizing transport would be beneficial only under certain flow regimes.		
		Adaptive Migration
Evaluated as Alternative 3 in the Feasibility Study.		
	A-6a	In-River Passage w/added Flow Augmentation
Eliminated during SCS Phase II. Path conducted a screening analysis of a similar alternative (A-6') and identified that in-river migration with the addition of SBCs performed worse than Maximum Transport. A BOR study was conducted to address added flow augmentation, however, the impact analysis conducted had an insufficient level of detail to be used in comparisons with other alternatives.		
	A-6b	In-River Passage w/no Flow Augmentation
Eliminated during SCS Phase II. Path conducted a screening analysis of a similar alternative (A-6') and identified that in-river migration with the addition of SBCs performed worse than Maximum Transport.		
	A-6d	In-River Passage
Eliminated during SCS Phase II. Path conducted a screening analysis of a similar alternative (A-6') and identified that in-river migration with the addition of SBCs performed worse than Maximum Transport.		
Natural River Drawdown Pathway – SCS Phase II		
A-3	A-3a	Dam Breaching
Evaluated as Alternative 4 in the Feasibility Study.		
	A-3b	Dam Removal
Eliminated during SCS Phase II. The intent of restoring the lower Snake River to a near natural river could be achieved at half the price. This alternative is not a cost effective option.		

Table 7-2. Feasibility Study Alternatives Matrix

	Alternative 1 – Existing Conditions	Alternative 2 – Maximum Transport	Alternative 3 – Major System Improvements	Alternative 4 – Dam Breaching
Existing System Operations				
Adult Fish Passage Systems				
Fish Ladders	√	√	√	
Pumped Attraction Water Supplies	√	√	√	
Powerhouse Fish Collection Systems	√	√	√	
Juvenile Fish Bypass and Collection Systems				
STS – IHR, LMO	√	√	√	
ESBS – LGO, LGR	√	√	√	
Collection & Transportation Facilities	√	√	√	
Trash Shear Boom	√	√	√	
Minimum Operating Pool – During Fish Migration	√	√	√	
Turbine Operations – Within 1 percent Peak Efficiency	√	√	√	
Voluntary Spill				
Current Operations	√			
Minimize Operations – IHR Only		√		
Optimize Operations			√	
No Spill				√
Flow Augmentation (Dworshak)	√	√	√	√
Flow Augmentation (Upper Snake River) – 427,000 acre-feet	√	√	√	√
Dissolved Gas Abatement Measures				
Spillway Gas Control Measures (Deflectors)	√	√	√	
Spillway Gas Monitoring	√	√	√	
Continue Fish Facility Operations	√	√	√	
Continue AFEP Evaluations	√	√	√	
Power				
Current Production	√		√	
Increased Production		√		
No Production				√
Navigation				
Current Operations	√	√	√	
No Operations				√
Fish Transportation				
Spread-the-Risk	√			
Optimize Transportation			√	
Maximize Transportation		√		
No Transportation				√

Table 7-2. Feasibility Study Alternatives Matrix

	Alternative 1 – Existing Conditions	Alternative 2 – Maximum Transport	Alternative 3 – Major System Improvements	Alternative 4 – Dam Breaching
lower Snake River Fish and Wildlife Compensation				
Current Wildlife Habitat Operations	√	√	√	√
Hatchery Program to Include Captive Broodstock	√	√	√	√
Recreation Requirements				
Current Operations	√	√	√	
Amended Operations				√
Existing System Upgrades				
Dissolved Gas Abatement Measures				
Add End-Bay Deflectors/Pier Extensions – LMO, LGO	√	√	√	
Modify Existing Deflectors – LMO, LGO, LGR	√		√	
Turbine Measures				
Install Turbine Minimum Gap Runners	√	√	√	
Miscellaneous Measures				
Upgrade Adult Fish Passage Systems	√	√	√	
Upgrade LGR Juvenile Fish Facility	√	√	√	
Flow Augmentation (Dworshak)	√	√	√	√
Flow Augmentation (Upper Snake) – 427,000 acre-feet	√	√	√	√
New Cylindrical Dewatering Screens	√	√	√	
Modify ESBS – LGO, LGR	√	√	√	
Additional Barges/Mooring Facilities - LGR	√	√	√	
New Wet Separators – LMO, LGO, LGR	√	√	√	
Major System Improvements				
Ice Harbor (IHR)				
Two RSWs w/BGS			√	
Replace STSs with ESBSs			√	
Lower Monumental Dam (LMO)				
Two-Unit Powerhouse Channel w/Dewatering			√	
Two RSWs with BGS			√	
Replace STSs with ESBSs			√	
Little Goose Dam (LGO)				
Full Length Powerhouse Occlusion			√	
Two RSWs			√	
Lower Granite Dam (LGR)				
Two-Unit Powerhouse Channel w/Dewatering			√	
Two RSWs			√	

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9. Glossary

Adaptive migration strategy—An approach that balances the passage of fish between in-river and transport methods. This strategy addresses concerns about risks and effectiveness associated with bypass-only and transport-only approaches. It allows flexibility for implementing operational changes within a migration season, if necessary.

Aesthetics—Of or pertaining to the sense of beautiful.

Air shed—A common air supply demarcated by a defined border.

Alternative 1—Existing Conditions—The existing hydrosystem operations under the National Marine Fisheries Service's 1995 and 1998 Biological Opinions. The Corps would continue to increase spill and manipulate spring and summer river flows as much as possible to assist juvenile salmon and steelhead migration. Juvenile salmon and steelhead would continue to pass the dams through the turbines, over spillways, or through the fish bypass systems. Transportation of juvenile fish via barge or truck would continue at its current level.

Alternative 2—Maximum Transport of Juvenile Salmon—The existing hydrosystem operations plus maximum transport of juvenile salmon, without surface bypass collectors. The number of juvenile fish transported via barge or truck would be increased to the maximum extent possible.

Alternative 3—Major System Improvements—The existing hydrosystem operations and adaptive migration measures for juvenile salmon and steelhead, but with additional major system improvements (such as surface bypass collectors) that could be accomplished without dam breaching.

Alternative 4—Dam Breaching—Near-natural river drawdown of the four lower Snake River reservoirs.

Ambient air quality standards (AAQSs)—Standards required by the Federal Clean Air Act and enforced by the U.S. Environmental Protection Agency that protect public health, provide for the most sensitive individuals, and allow a margin of safety by setting an acceptable level for measured pollutant concentrations. AAQSs cannot take into account the cost of achieving the standards.

Ammoceote—The larva of anadromous lamprey, which develop in freshwater streams, then migrate to the ocean.

Anadromous fish—Fish, such as salmon or steelhead trout, that hatch in fresh water, migrate to and mature in the ocean, and return to fresh water as adults to spawn.

Behavioral guidance structure (BGS)—A long, steel, floating structure designed to simulate the natural shoreline and guide fish toward the surface bypass collection system by taking advantage of their natural tendency to follow the shore.

Bulkhead channel—Channel through which fish are carried upward through the turbines via a bulkhead slot if they are not diverted by turbine intake screens.

Bypass channel—Fish diverted from turbine passage are directed through a bypass channel to a holding area for release or loading onto juvenile fish transportation barges or trucks.

Collection channel—Holding area within the powerhouse that fish enter after exiting the bulkhead slot.

Columbia River Salmon Passage (CRiSP)—The passage model developed by the Center for Quantitative Studies at the University of Washington under contract to the Bonneville Power Administration.

Cultural resources—Archaeological and historical sites, historic architecture and engineering, and traditional cultural properties.

Cumulative Risk Initiative (CRI)—A network of National Marine Fisheries Services scientists working to synthesize information and provide a clear, consistent, and scientifically rigorous decision support for salmonid conservation. The CRI has used matrix modeling of salmonid population dynamics to evaluate extinction risks and the sensitivity of population growth for each ESU to changes in survival as a result of management actions.

Decommission—To take the dams and associated facilities out of service such that they are not in use or working condition.

Differential delayed transportation mortality—Additional mortality suffered by transported fish after their release from the transport vehicle into the Columbia River below Bonneville Dam—hypothesized to be caused by stresses associated with the transportation system. Differential mortality is measured as the ratio of the post-Bonneville-Dam survival of transported fish to that of non-transported fish. Delayed transportation mortality is differentiated from any direct mortality of fish that occurs during transportation.

Dissolved gas supersaturation—Caused when water passing through a dam's spillway carries trapped air deep into the waters of the plunge pool, increasing pressure and causing the air to dissolve into the water. Deep in the pool, the water is "supersaturated" with dissolved gas compared to the conditions at the water's surface.

Drawdown—In the context of this FR/EIS, drawdown means returning the lower Snake River to its near-natural condition via dam breaching.

D-values—Measure used to quantify differential delayed transportation mortality. A D-value of 1.0 would mean that there was no differential delayed transportation mortality (there could be mortality; it is just no different between transported and non-transported fish). The lower the value of D (relative to 1.0), the larger the differential delayed transportation mortality. It is possible for D to be greater than 1 (in which case transported fish would have survived at a higher rate than non-transported fish).

Endangered species—A native species found by the Secretary of the Interior or the Secretary of Commerce to be threatened with extinction.

Extra mortality—Any mortality occurring outside the migration corridor (i.e., below Bonneville Dam) that is not accounted for by in-common climate effects or by differential delayed transportation mortality.

Fauna—A general term for animal life.

Federal Columbia River Power System (FCRPS)—Official term for the 14 Federal dams on the Columbia and Snake Rivers.

Fish collection/handling facility—Holding area where juvenile salmon and steelhead are separated from adult fish and debris by a separator and then passed to holding ponds or raceways until they are loaded onto juvenile fish transportation barges or trucks.

Fish guidance efficiency (FGE)—Percent of juvenile salmon and steelhead diverted away from the turbines by submersed screens or other structures.

Fish leaving under several hypotheses (FLUSH)—The passage model developed by the states of Oregon, Washington, and Idaho and the Columbia River Intertribal Fish Commission.

Fish passage efficiency (FPE)—Portion of all juvenile salmon and steelhead passing a facility that do not pass through the turbines.

Flow augmentation—Increasing river flows above levels that would occur under normal operation by releasing more water from storage reservoirs upstream.

Habitat—An area that provides some portion of the requirements for the life history of a given species.

Irrigation—Artificial application of water to usually dry land for agricultural use.

Juvenile fish transportation system (JFT)—System of barges and trucks used to transport juvenile salmon and steelhead from the lower Snake River or McNary Dam to below Bonneville Dam for release back into the river; alternative to in-river migration.

Lock—A chambered structure on a waterway closed off with gates for the purpose of raising or lowering the water level within the lock chamber so ships can move from one elevation to another along the waterway.

Loessal soils—Soil capable of being transported and deposited by wind and consisting predominantly of silt size particles.

Lower Snake River Project (LSRP)—The four hydropower facilities operated by the Corps on the lower Snake River: Lower Granite, Little Goose, Lower Monumental, and Ice Harbor.

Minimum operating pool (MOP)—The bottom one foot of the operating range for each reservoir. The reservoirs normally have a 3-foot to 5-foot operating range.

Mitigation—To moderate or compensate for an impact or effect.

Natal stream—Stream of origin.

Navigation—Method of transporting commodities via waterways; usually refers to transportation on regulated waterways via a system of dams and locks.

Near-natural river—A river or definitive segment of river which has a natural geomorphological appearance, however, the river is regulated by some type of man-made control structure(s) which influence the hydrograph and/or the floodplain.

Nonattainment areas—Geographic areas with measured pollutant concentrations greater than the ambient air quality standards.

Passive use value—The value that individuals place on the mere existence of something. Passive use values are the benefit received from simply knowing that the resources exists even if no use is made of it. Also known as existence value.

Ocean regime shift—Cycle of oceanographic conditions that alters patterns of circulation, the distribution of predators and prey, and productivity. Cycles have been observed on the timescale of years (El Niño), decades (Pacific interdecadal oscillations), and thousands of years (ice ages). The current ocean regime, and a shift on the timescale of years or decades, may affect the likelihood of recovery under any hydrosystem management alternative.

Passage model—Mathematical simulation of the effect of downstream passage (through eight Federal mainstem hydro projects) on the survival of juvenile salmonids. PATH used two passage models; CRiSP and FLUSH (see above). The models differ both in their mathematical structure and in assumptions about survival through various parts of the hydrosystem (see page 25 in Marmorek and Peters [1998] *[March 1998 report]* for a brief comparison).

Plan for Analyzing and Testing Hypotheses (PATH)—A work group of regional fisheries biologists that measure projected salmon and steelhead survival rates associated with alternative actions.

Pumping stations—Facilities that draw water through intake screens in the reservoir and pump the water uphill to corresponding distribution systems for irrigation and other purposes.

Reasonable and Prudent Alternative (RPA)—Alternative to a proposed or continuing action when that action is likely to jeopardize the continued existence of a listed species or destroy or adversely modify its critical habitat.

Recovery—The process by which the ecosystem is restored so it can support self-sustaining and self-regulating populations of listed species as persistent members of the native biotic community. This process results in improvement in the status of a species to the point at which listing is no longer appropriate under the Endangered Species Act.

Removable spillway weir (RSW)—A removable steel structure that is attached to the forebay of an existing spill bay, creating a raised overflow weir above and upstream of the existing spillway crest.

Resident fish—Fish species that reside in fresh water throughout their lifecycle.

Run-of-river—This describes hydropower facilities that do not have storage or the associated flood control capacity; run-of-river facilities essentially pass through as much water as they have coming in, either through the turbines or over the spillways.

Scouring—Concentrated erosive action, especially by stream or river water, as on the outside curve of a bend.

Simulated Wells Intake (SWI)—Modified turbine intake that draws water from below the surface so that the surface is calmer and juvenile fish are less influenced by turbine flows. This allows juvenile fish more opportunity to discover and enter the surface bypass collection system.

Slumping—A landslide; the separation of a land or soil mass from a land surface and its movement downslope.

Spawning—The reproductive process for aquatic organisms which involves producing or depositing eggs or discharging sperm.

Spill—Water released through the dam spillways, rather than through the turbines. Involuntary spill occurs when reservoirs are full and flows exceed the capacity of the powerhouse or power output needs. Voluntary spill is one method used to pass juvenile fish without danger of turbine passage.

Spillway flow deflectors (flip lips)—Structures that limit the plunge depth of water over the dam spillway, producing a less forceful, more horizontal spill. These structures reduce the amount of dissolved gas trapped in the spilled water.

Spread-the-Risk—Spreading the risk of negative outcomes among alternative routes of hydroelectric passage for juvenile salmonids. Intended to prevent a recovery action that is designed to improve survival of one listed species from becoming a factor in the decline of another species.

Surface bypass collector (SBC) system—System designed to divert fish at the surface before they have to dive and encounter the existing turbine intake screens. SBCs direct the juvenile fish into the forebay, where they are passed downstream either through the dam spillway or via the juvenile fish transportation system of barges and trucks.

Survival—The species' persistence beyond the conditions leading to its endangerment, with sufficient resilience to allow for potential recovery from endangerment. The condition in which a species continues to exist into the future while retaining the potential for recovery.

Threatened species—A native species likely to become endangered within the foreseeable future.

Total suspended solids (TSS)—The portion of the sediment load suspended in the water column. The grain size of suspended sediment is usually less than one millimeter in diameter (clays and

silts). High TSS concentrations can adversely affect primary food production and fish feeding efficiency. Extremely high TSS concentrations can impair other biological functions such as respiration and reproduction.

Turbidity—An indicator of the amount of sediment suspended in water. It refers to the amount of light scattered or absorbed by a fluid. In streams or rivers, turbidity is affected by suspended particles of silts and clays, and also by organic compounds like plankton and microorganisms. Turbidity is measured in nephelometric turbidity units.

Turbine intake screens—Standard-length traveling fish screens or extended-length submerged bar screens that are lowered into the turbine bulkhead slots to divert fish from the turbine intake.

Turbine intakes—Water intakes for each generating unit at a hydropower facility.

ANNEX A

RESOURCE EFFECTS ANALYSIS

Table A-1. Resource Effects Analysis – Geology and Soils

ALTERNATIVES			
1—EXISTING CONDITIONS	**2—MAXIMUM TRANSPORT**	**3—MAJOR SYSTEM IMPROVEMENTS**	**4—DAM BREACHING**
DIRECT AND INDIRECT EFFECTS	**DIRECT AND INDIRECT EFFECTS**	**DIRECT AND INDIRECT EFFECTS**	**DIRECT AND INDIRECT EFFECTS**
Natural hill slope erosion would continue at existing rates.	Natural hill slope erosion would continue at existing rates.	Natural hill slope erosion would continue at existing rates.	There would be an exposure of approximately 14,000 acres of inundated lands.
Wave-induced erosion on reservation banks would continue at existing rates.	Wave-induced erosion on reservation banks would continue at existing rates.	Wave-induced erosion on reservation banks would continue at existing rates.	The sloughing/erosion of mudflats/oversteepened banks would be expected to increase.
There would be no adverse effects to soil resources.	There would be no adverse effects to soil resources.	There would be no adverse effects to soil resources.	Roadway/railroad embankment failures would also be expected to increase. A total of 68 potential slope failure areas have been identified. Natural hill slope erosion would continue at existing rates.
CUMULATIVE EFFECTS	**CUMULATIVE EFFECTS**	**CUMULATIVE EFFECTS**	**CUMULATIVE EFFECTS**
No cumulative effects identified.	No new cumulative effects identified.	No new cumulative effects identified.	In the short term (5 to 10 years), increased sloughing and erosion of exposed mudflats and oversteepened banks would contribute to higher Total Suspended Solids (TSS) concentrations. This action would move into the long term, however, on a seasonable basis during periods of high runoff. The sloughing of natural slopes or hillsides would occur as dictated by nature and contribute to TSS in the long term.
ISSUES	**ISSUES**	**ISSUES**	**ISSUES**
No significant issues identified.	No significant issues identified.	No significant issues identified.	The period of exposure of the newly exposed saturated embankments would cause road and rail failures until riprap could be adequately placed.

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Table A-2. Resource Effects Analysis – Air Quality

ALTERNATIVES			
1—EXISTING CONDITIONS	**2—MAXIMUM TRANSPORT**	**3—MAJOR SYSTEM IMPROVEMENTS**	**4—DAM BREACHING**
DIRECT AND INDIRECT EFFECTS	**DIRECT AND INDIRECT EFFECTS**	**DIRECT AND INDIRECT EFFECTS**	**DIRECT AND INDIRECT EFFECTS**
The lower Snake River region would continue to generally meet the ambient air quality standards (AAQSs). Industrial emissions are the primary source of gaseous criteria air pollutants, toxic air pollutants (TAPs), and greenhouse gases (GHGs) in the lower Snake River Basin. The Wallula area is a particulate matter with aerodynamic diameters less than 10 micrometers (PM_{10}) nonattainment area due largely to fugitive dust.	The lower Snake River region would continue to generally meet the AAQSs. Industrial emissions are the primary source of gaseous criteria air pollutants, TAPS, and GHGs in the lower Snake River Basin. The Wallula area is a PM_{10} nonattainment area due largely to fugitive dust.	The lower Snake River region would continue to generally meet the AAQSs. Industrial emissions are the primary source of gaseous criteria air pollutants, TAPS, and GHGs in the lower Snake River Basin. The Wallula area is a PM_{10} nonattainment area due largely to fugitive dust.	Construction-related fugitive emissions would generate an added 305 tons per year (TPY) of PM_{10} for the deconstruction of the for Lower Snake River Project the years of construction. Change in transportation-related emissions shows a 15 TPY decrease in carbon monixide (CO), a 90 TPY increase in volatile organic compound (VOC), a 20 TPY decrease in nitrogen oxides (NO_x), a 9 TPY increase in PM_{10}, and a 71 TPY decrease in sulfur dioxide (SO_2). An increase in fugitive dust from the approximately 14,000 acres of newly exposed acres would be estimated at PM_{10} emissions of 6,292 TPY. Replacement power emissions would be estimated to increase from 0.39 to 1.1 percent depending on the individual pollutant. The pollutant breakdown includes the following: CO increase by 4,489 TPY; carbon dioxide (CO_2) increase by 4,636,511 TPY; SO_2 increase by 2,204 TPY; and an increase in NO_x, PM_{10}, VOCs, benzene, and formeldehyde. If Zero Carbon Options were implemented, these emissions would not apply.
CUMULATIVE EFFECTS	**CUMULATIVE EFFECTS**	**CUMULATIVE EFFECTS**	**CUMULATIVE EFFECTS**
A large amount of the interior plateau near the Columbia and Snake Rivers is dominated by fine-grained loessal soils that are susceptible to wind erosion. Prevailing wind is from the southwest moving at an average of 7 to 8 mph.	A large amount of the interior plateau near the Columbia and Snake Rivers is dominated by fine-grained loessal soils that are susceptible to wind erosion. Prevailing wind is from the southwest moving at an average of 7 to 8 mph.	A large amount uch of the interior plateau near the Columbia and Snake Rivers is dominated by fine-grained loessal soils that are susceptible to wind erosion. Prevailing wind is from the southwest moving at an average of 7 to 8 mph.	The type of replacement power or its siting cannot be determined by this study; therefore, detailed analysis on impacts would be dependent upon the processes described for initiation of such power development systems. There may be a possible decrease in industrial emissions. This would be assuming that the industry would shut down. A possible increase or decrease in farm emissions may also occur.
ISSUES	**ISSUES**	**ISSUES**	**ISSUES**
What would be the effect of actions at Wallula regarding air sheds? More analysis of air shed conditions is warranted.	What would be the effect of actions at Wallula regarding air sheds? More analysis of air shed conditions is warranted.	What would be the effect of actions at Wallula regarding air sheds? More analysis of air shed conditions is warranted.	What would be the effect of actions at Wallula regarding air sheds? How quickly can replacement power take over? To what extent would changes in agricultural practices due to increased power costs cause impacts to air quality? Would businesses providing products such as fertilizers which can affect air quality continue to survive? Implementation of Zero Carbon Options would likely require government intervention to overcome certain implementation hurdles (i.e., user conservation).

Table A-3. Resource Effects Analysis – Water Resources: Temperature

ALTERNATIVES			
1—EXISTING CONDITIONS	2—MAXIMUM TRANSPORT	3—MAJOR SYSTEM IMPROVEMENTS	4—DAM BREACHING
DIRECT AND INDIRECT EFFECTS	**DIRECT AND INDIRECT EFFECTS**	**DIRECT AND INDIRECT EFFECTS**	**DIRECT AND INDIRECT EFFECTS**
Maximum water temperature each year reaches approximately 23 degrees Celsius. There is a large temperature variation within the reservoir. Reservoir temperatures would warm slower and cool slower than natural river temperatures.	Maximum water temperature each year reaches approximately 23 degrees Celsius. There is a large temperature variation within the reservoir. Reservoir temperatures would warm slower and cool slower than natural river temperatures.	Maximum water temperature each year reaches approximately 23 degrees Celsius. There is a large temperature variation within the reservoir. Reservoir temperatures would warm slower and cool slower than natural river temperatures.	Maximum water temperature each year reaches approximately 23 degrees Celsius. Natural river temperatures would warm faster and cool faster.
CUMULATIVE EFFECTS	**CUMULATIVE EFFECTS**	**CUMULATIVE EFFECTS**	**CUMULATIVE EFFECTS**
Continued operation of the project would not change current water temperature regimes downstream of the lower Snake Rvier dams.	No change from current condition.	No change from current condition.	Changes to water temperatures downstream of the lower Snake River dams would probably be minor because the Snake River merges with the Columbia River, which has a much greater flow.
ISSUES	**ISSUES**	**ISSUES**	**ISSUES**
Water temperature concerns continue to be addressed in a regional context by a variety of agencies and other entities.	Water temperature concerns continue to be addressed in a regional context by a variety of agencies and other entities.	Water temperature concerns continue to be addressed in a regional context by a variety of agencies and other entities.	Water temperature concerns continue to be addressed in a regional context by a variety of agencies and other entities.

Table A-4. Resource Effects Analysis – Water Resources: Dissolved Gas

ALTERNATIVES			
1—EXISTING CONDITIONS	**2—MAXIMUM TRANSPORT**	**3—MAJOR SYSTEM IMPROVEMENTS**	**4—DAM BREACHING**
DIRECT AND INDIRECT EFFECTS	**DIRECT AND INDIRECT EFFECTS**	**DIRECT AND INDIRECT EFFECTS**	**DIRECT AND INDIRECT EFFECTS**
Total dissolved gas (TDG) levels typically reach 115 to 130 percent each year during annual spring period when lower Snake River flows exceed power plant capacities at the dams and large amounts of water are released through the spillbays (involuntary spill).	TDG levels typically reach 115 to 130 percent each year during annual spring period when lower Snake River flows exceed power plant capacities at the dams and large amounts of water are released through the spillbays (involuntary spill).	TDG levels typically reach 115 to 130 percent each year during annual spring period when lower Snake River flows exceed power plant capacities at the dams and large amounts of water are released through the spillbays (involuntary spill).	TDG levels anticipated to be found in the lower Snake River would be similar to those found above the existing Lower Granite Lake, which is 110 percent or less.
TDG levels typically reach 115 to 120 percent each year and are operated to those levels as water is released through spillbays to assist in fish passage (voluntary spill).	Voluntary spill would not occur. This would reduce TDG levels to or below 110 percent at Lower Granite, Little Goose, and Lower Monumental. Voluntary spill would still occur at Ice Harbor.	TDG levels typically reach 115 to 120 percent each year and are operated to those levels as water is released through spillbays to assist in fish passage (voluntary spill).	
CUMULATIVE EFFECTS	**CUMULATIVE EFFECTS**	**CUMULATIVE EFFECTS**	**CUMULATIVE EFFECTS**
TDG levels begin to disipate as they move through the reservoirs from one dam to the next. However, the levels never totally disappear, so there is some build up of the TDG levels as water passes through a series of dams.	TDG levels begin to disipate as they move through the reservoirs from one dam to the next. However, the levels never totally disappear, so there is some build up of the TDG levels as water passes through a series of dams.	TDG levels begin to disipate as they move through the reservoirs from one dam to the next. However, the levels never totally disappear, so there is some build up of the TDG levels as water passes through a series of dams.	Higher turbulence associated with a more natural river would bring dissolved gas into a state of equilibrium more quickly.
ISSUES	**ISSUES**	**ISSUES**	**ISSUES**
Endangered Species Act (ESA) requirements as presented in the 2000 Biological Opinion. Without waivers to 115 to 120 percent, the Washington State standards would be in conflict with this opinion.	Endangered Species Act (ESA) requirements as presented in the 2000 Biological Opinion. Without waivers to 115 to 120 percent, the Washington State standards would be in conflict with this opinion.	Endangered Species Act (ESA) requirements as presented in the 2000 Biological Opinion. Without waivers to 115 to 120 percent, the Washington State standards would be in conflict with this opinion.	

Table A-5. Resource Effects Analysis – Water Resources: Sedimentation

ALTERNATIVES			
1—EXISTING CONDITIONS	2—MAXIMUM TRANSPORT	3—MAJOR SYSTEM IMPROVEMENTS	4—DAM BREACHING
DIRECT AND INDIRECT EFFECTS	**DIRECT AND INDIRECT EFFECTS**	**DIRECT AND INDIRECT EFFECTS**	**DIRECT AND INDIRECT EFFECTS**
Lower Granite would continue to receive an average inflowing sediment load of 3 to 4 million cubic yards (MCY) each year.	Lower Granite would continue to receive an average inflowing sediment load of 3 to 4 MCY each year.	Lower Granite would continue to receive an average inflowing sediment load of 3 to 4 MCY each year.	Approximately 50 percent (50 to 75 MCY) of the total sediment deposited within the lower Snake River (since Ice Harbor's completion in 1962) would be moved to McNary in the first few years following dam breaching. Annual inflowing sediment would not be significantly accumulated within the lower 140-mile reach of the Snake River.
Ice Harbor and Little Goose would accumulate small amounts of fine sediment.	Ice Harbor and Little Goose would accumulate small amounts of fine sediment.	Ice Harbor and Little Goose would accumulate small amounts of fine sediment.	
Lower Monumental would receive sediment from the Palouse and Tucannnon Rivers.	Lower Monumental would receive sediment from the Palouse and Tucannnon Rivers.	Lower Monumental would receive sediment from the Palouse and Tucannnon Rivers.	There would be an increase in dredging McNary to clear private lanes and water intakes.
CUMULATIVE EFFECTS	**CUMULATIVE EFFECTS**	**CUMULATIVE EFFECTS**	**CUMULATIVE EFFECTS**
Navigation within certain Lower Granite Lake locations would require dredging to maintain the navigation channel. Over time reservoir freeboard would continue to be reduced if non-navigation dredging did not occur.	Navigation within certain Lower Granite Lake locations would require dredging to maintain the navigation channel. Over time reservoir freeboard would continue to be reduced if non-navigation dredging did not occur.	Navigation within certain Lower Granite Lake locations would require dredging to maintain the navigation channel. Over time reservoir freeboard would continue to be reduced if non-navigation dredging did not occur.	All the sediment problems that exist in the Lower Snake River Project would be shifted to Lake Wallula.
ISSUES	**ISSUES**	**ISSUES**	**ISSUES**
National Marine Fisheries Service (NMFS) has determined that future dredging activities would have adverse effects on the salmon and steelhead.	National Marine Fisheries Service (NMFS) has determined that future dredging activities would have adverse effects on the salmon and steelhead.	National Marine Fisheries Service (NMFS) has determined that future dredging activities would have adverse effects on the salmon and steelhead.	Rate of sediment deposition, along with location for deposition, is estimated; therefore, direct site impacts are unclear.

Table A-6. Resource Effects Analysis – Water Resources: Contaminants

ALTERNATIVES			
1—EXISTING CONDITIONS	**2—MAXIMUM TRANSPORT**	**3—MAJOR SYSTEM IMPROVEMENTS**	**4—DAM BREACHING**
DIRECT AND INDIRECT EFFECTS	**DIRECT AND INDIRECT EFFECTS**	**DIRECT AND INDIRECT EFFECTS**	**DIRECT AND INDIRECT EFFECTS**
Contaminants of concern would likely include: ammonia, manganese, total DDT, and dioxin TEQ.	Contaminants of concern would likely include: ammonia, manganese, total DDT, and dioxin TEQ,	Contaminants of concern would likely include: ammonia, manganese, total DDT, and dioxin TEQ.	Contaminants of concern would likely include: ammonia, manganese, total DDT, and dioxin TEQ.
Chemical contaminants which could exist would be locked in the sediments. As long as the sediments remained undisturbed, the chemicals would cause little concern.	Chemical contaminants which could exist would be locked in the sediments. As long as the sediments remained undisturbed the chemicals would cause little concern.	Chemical contaminants which could exist would be locked in the sediments. As long as the sediments remained undisturbed, the chemicals would cause little concern.	The contaminants would be resuspended with the sediment during drawdown and would remain in suspension as well as be resuspended over a period of several years after dam breaching until the river normalizes. There may be the potential for these contaminants to cause problems while in suspension. This potential may include toxicity to aquatic life.
CUMULATIVE EFFECTS	**CUMULATIVE EFFECTS**	**CUMULATIVE EFFECTS**	**CUMULATIVE EFFECTS**
The continued operations of the Lower Snake River Project would not change the current status of contaminants.	The continued operations of the Lower Snake River Project would not change the current status of contaminants.	The continued operations of the Lower Snake River Project would not change the current status of contaminants.	The contaminant conditions within Lake Wallula would worsen due increased input from the Lower Snake River Project. Lower Snake River Project problems would be transferred to Lake Walulla.
ISSUES	**ISSUES**	**ISSUES**	**ISSUES**
The overall presence of contaminants within the Lower Snake River Project reservoirs is unknown. Current knowledge is based on a series of point samples.	The overall presence of contaminants within the Lower Snake River Project reservoirs is unknown. Current knowledge is based on a series of point samples.	The overall presence of contaminants within the Lower Snake River Project reservoirs is unknown. Current knowledge is based on a series of point samples.	Prior to any dam breaching and drawdown of the reservoirs, it would be necessary to do an intensive study of sediments within the Lower Snake River Project to better understand the distribution of the contaminants of concern.

Table A-7. Resource Effects Analysis – Aquatic Resources: Spring/Summer Chinook

ALTERNATIVES			
1—EXISTING CONDITIONS	**2—MAXIMUM TRANSPORT**	**3—MAJOR SYSTEM IMPROVEMENTS**	**4—DAM BREACHING**
DIRECT AND INDIRECT EFFECTS	**DIRECT AND INDIRECT EFFECTS**	**DIRECT AND INDIRECT EFFECTS**	**DIRECT AND INDIRECT EFFECTS**
There is a moderate probability that the Snake River spring/summer chinook salmon would show a minimal, insignificant survival increase through the Lower Snake River Project passage for Alternatives 1 through 3.	Smolt transportation would only be as beneficial as in-river smolt survival would be bad. As long as the D value were greater than in-river survival, the transport for that water year would be beneficial. Transported smolt survival would increase with lower flow years and post-mid-May releases when smolts are more fit and vigorous. This is when they are larger in size and the near-ocean current shifts with the wind to a more nutrient-rich distribution.	There are insufficient data from the Snake River to assess the effectiveness in increasing adult returns. The effectiveness from McNary is positive.	There is a high probability that spring/summer chinook would show marked survival and population growth because the survival would partially be dependent upon the spring warming trend in water temperature. The overwintering survival for a portion of the population would increase. In 5 to 10 years, productivity of the food-web diversity would increase to the high production of the unimpounded Hells Canyon reach. The coolwater of Dworshak could negate. The current passage survivals with transport under the high D value may give a slightly less than estimated adult return with dam breaching. There is increasing evidence to indicate that the Snake River spring/summer chinook salmon use mainstem habitat for overwintering. Mainstem habitat would increase under dam breaching, but it would require the active management of near-natural flow shaping, timing, and magnitude in order to keep the habitat maintained.
CUMULATIVE EFFECTS	**CUMULATIVE EFFECTS**	**CUMULATIVE EFFECTS**	**CUMULATIVE EFFECTS**
Corps has deferred its major maintenance and rehabilitation program to a point of critical mass. Ice Harbor needs turbines. Lower Monumental needs a stilling basin. Continuation to defer these maintenance items may be negative to fish. National Marine Fisheries Service (NMFS) has determined that future dredging activities would have adverse effects on the salmon and steelhead. Future dredging would also be required thorough the examination of impacts.	Corps has deferred its major maintenance and rehabilitation program to a point of critical mass. Ice Harbor needs turbines. Lower Monumental needs a stilling basin. Continuation to defer these maintenance items may be negative to fish. National Marine Fisheries Service (NMFS) has determined that future dredging activities would have adverse effects on the salmon and steelhead. Future dredging would also be required thorough the examination of impacts.	Corps has deferred its major maintenance and rehabilitation program to a point of critical mass. Ice Harbor needs turbines. Lower Monumental needs a stilling basin. Continuation to defer these maintenance items may be negative to fish. NMFS has determined that future dredging activities would have adverse effects on the salmon and steelhead. Future dredging would also require a thorough examination of impacts.	Dam breaching and adaptive management of coolwater release regimes from Dworshak would result in increased smolt condition and fitness relating to increased survival to the ocean and then the return to the Snake River. NMFS Cumulative Risk Initiative (CRI) shows salmon survival is dependent upon production variants such as growth for all lifestages including 1st year growth and fitness to survive hydrosystem, estuary, and near-ocean conditions
ISSUES	**ISSUES**	**ISSUES**	**ISSUES**
Coolwater releases from Dworshak for flow target and water temperature regulation critically needs re-evaluation for scientific justification of how and when to schedule for best growth and condition of smolts.	Coolwater releases from Dworshak for flow target and water temperature regulation critically needs re-evaluation for scientific justification of how and when to schedule for best growth and condition of smolts. Delayed mortality vectors would be significant. The idea that the "current fish transport program is effective at increasing adult returns" is an overgeneralization. The timing and date of release is important due to smolt size and fitness and degree of smoltification. All survival and recovery standard transport's metrics performance is dependent upon what is distribution of D values and in-river's extra mortality (not zero). Only increased effort in research and monitoring can resolve the uncertainties regarding delayed and extra mortality. There would likely not be enough information to address these issues by the 3-, 5-, or even 8-year evaluation dates established in the 2000 BiOp to facilitate Adaptive Management and Spread-the-Risk Policy.	Coolwater releases from Dworshak for flow target and water temperature regulation critically needs re-evaluation for scientific justification of how and when to schedule for best growth and condition of smolts. Structural manipulation of the hydrosystem has reached its critical mass. No new fixes at affordable prices are left to tweak in prototype research (Independent Scientific Advisory Board [ISAB], NMFS 2000 BiOp). Relatively high dam passage survivals exist. Reservoir survival and post-hydrosystem survival are critical. The subyearlings reaction to a surface bypass collector (SBC) or removable spillbay wier (RSW) would need to be evaluated. Subyearling behavior is for deeper passage, which might suggest that the extended submerged bar screen (ESBS) might be equal to or even more beneficial than other bypass and collection measures.	The D value does not functionally exist with dam breaching, but extra mortality in model error terms remains. Adaptive (spread-the-risk) Management has run its course as a failed, statistically confusing management scheme. Adaptive Management takes too many years without resulting in an identification of significant causal effects. Sediment management would be required for up to 5 years following breach. Alternative 4, "uncertainties" with sediment, can be tested via experimental management by breaching 1 to 2 dams that are not maintained. Rehabilitation construction impacts are long-term actions resulting in critical "adverse effects" to salmonid populations and production. In-water construction activities required for shoreline protection (levees, riprap relocation, etc.) would continue post-breach. Post-breach land ownership and permitted use would be critical to the success of goals and objectives. Active management of restoring habitat components with flow management would have to be emphasized.

Table A-8. Resource Effects Analysis – Aquatic Resources: Fall Chinook

ALTERNATIVES			
1—EXISTING CONDITIONS	**2—MAXIMUM TRANSPORT**	**3—MAJOR SYSTEM IMPROVEMENTS**	**4—DAM BREACHING**
DIRECT AND INDIRECT EFFECTS	**DIRECT AND INDIRECT EFFECTS**	**DIRECT AND INDIRECT EFFECTS**	**DIRECT AND INDIRECT EFFECTS**
There is a moderate probability that the Snake River fall chinook salmon would show a minimal, insignificant survival increase through the Lower Snake River Project passage for Alternatives 1 through 3. Maximized spill would be unnecessary due to the no net increase in survival benefits. Exceedance frequency of 110 percent total dissolved gas (TDG) would be unacceptable.	There are insufficient data from the Snake River to assess effectiveness in increasing adult returns. The effectiveness from McNary is positive. Smolt transportation only would be as beneficial as in-river smolt survival would be bad. As long as the D value is greater than in-river survival, the transport for that water year would be beneficial. Transported smolt survival would increase with lower flow years.	There are insufficient data from the Snake River to assess the effectiveness in increasing adult returns. The effectiveness from McNary is positive. Optimized voluntary spill would be beneficial to in-river smolt survival. Maximized spill would be unnecessary due to the no net increase in survival benefits. Exceedance frequency of 110 percent TDG would be unacceptable.	There is a high probability that fall chinook would show marked survival and population growth. Mainstem habitat would increase under dam breaching, but it would require the active management of near-natural flow shaping, timing, and magnitude in order to keep the habitat maintained.
CUMULATIVE EFFECTS	**CUMULATIVE EFFECTS**	**CUMULATIVE EFFECTS**	**CUMULATIVE EFFECTS**
Corps has deferred its major maintenance and rehabilitation program to a point of critical mass. Ice Harbor needs turbines. Lower Monumental needs a stilling basin. Continuation to defer these maintenance items may be negative to fish. NMFS has determined that future dredging activities would have adverse effects on the salmon and steelhead. Future dredging would also be required thorough the examination of impacts.	Corps has deferred its major maintenance and rehabilitation program to a point of critical mass. Ice Harbor needs turbines. Lower Monumental needs a stilling basin. Continuation to defer these maintenance items may be negative to fish. NMFS has determined that future dredging activities would have adverse effects on the salmon and steelhead. Future dredging would also be required thorough the examination of impacts.	Corps has deferred its major maintenance and rehabilitation program to a point of critical mass. Ice Harbor needs turbines. Lower Monumental needs a stilling basin. Continuation to defer these maintenance items may be negative to fish. NMFS has determined that future dredging activities would have adverse effects on the salmon and steelhead. Future dredging would also be required thorough the examination of impacts.	Dam breaching and adaptive management of coolwater release regimes from Dworshak would result in increased smolt condition and fitness relating to increased survival to the ocean and the return to the Snake River. NMFS CRI shows salmon survival dependent upon production variants such as growth for all lifestages including 1st year growth and fitness to survive hydrosystem, and estuary and near-ocean conditions.
ISSUES	**ISSUES**	**ISSUES**	**ISSUES**
Coolwater releases from Dworshak for flow target and water temperature regulation critically needs re-evaluation for scientific justification of how and when to schedule for best growth and condition of smolts.	Coolwater releases from Dworshak for flow target and water temperature regulation critically needs re-evaluation for scientific justification of how and when to schedule for best growth and condition of smolts. Delayed mortality vectors would be significant. The idea that "current fish transport program is effective at increasing adult returns" is an overgeneralization. The timing and date of release important due to smolt size and fitness and degree of smoltification. All survival and recovery standard transport's metrics performance dependent upon what is distribution of D values and in-river's extra mortality (not zero). Only increased effort in research and monitoring can resolve the uncertainties regarding delayed and extra mortality. There would likely not be enough information to address these issues by the 3-, 5-, or even 8-year evaluation dates established in the 2000 BiOp to facilitate Adaptive Management and Spread-the-Risk Policy.	Coolwater releases from Dworshak for flow target and water temperature regulation critically needs re-evaluation for scientific justification of how and when to schedule for best growth and condition of smolts. Structural manipulation of the hydrosystem has reached its critical mass. No new fixes at affordable prices are left to tweak in prototype research (ISAB, NMFS 2000 BiOp). Relatively high dam passage survivals exist, reservoir survival and post-hydrosystem survival are critical. The subyearlings reaction to an SBC or RSW still needs to be evaluated. Subyearling behavior is for deeper passage, which might suggest that the ESBS might be equal to or even more beneficial than other bypass and collection measures.	The D value does not functionally exist with dam breach, but extra mortality in model error terms remains. Adaptive (spread-the-risk) Management has run its course as a failed, statistically confusing management scheme. Adaptive Management takes too many years without resulting in an identification of significant causal effects. Sediment management would be required for up to 5 years following breach. Alternative 4, "uncertainties" with sediment, can be tested via experimental management by breaching 1 to 2 dams that are not maintained. Rehabilitation construction impacts are long-term actions resulting in critical "adverse effects" to salmonid populations and production. In-water construction activities required for shoreline protection (levees, riprap relocation, etc.) would continue post-breach. Post-breach land ownership and permitted use would be critical to the success of goals and objectives. Active management of restoring habitat components with flow management would have to be emphasized.

Table A-9. Resource Effects Analysis – Aquatic Resources: Steelhead

ALTERNATIVES			
1—EXISTING CONDITIONS	**2—MAXIMUM TRANSPORT**	**3—MAJOR SYSTEM IMPROVEMENTS**	**4—DAM BREACHING**
DIRECT AND INDIRECT EFFECTS	**DIRECT AND INDIRECT EFFECTS**	**DIRECT AND INDIRECT EFFECTS**	**DIRECT AND INDIRECT EFFECTS**
There is a moderate probability that Snake River Basin steelhead would show a minimal, insignificant survival increase through the Lower Snake River Project passage for Alternatives 1 through 3. Maximized spill would be unnecessary due to the no net increase in survival benefits. Exceedance frequency of 110 percent TDG would be unacceptable.	Smolt transportation would only be as beneficial as in-river smolt survival would be bad. As long as the D value is greater than in-river survival, the transport for that water year would be beneficial. Transported smolt survival would increase with lower flow years and post mid-May releases when smolts are more fit and viguorous. This is when they are larger in size and the near-ocean current shifts with the wind to a more nutrient-rich distribution.	Optimized voluntary spill would be beneficial to in-river smolt survival. Maximized spill would be unnecessary due to the no net increase in survival benefits. Exceedance frequency of 110 percent TDG would be unacceptable.	There is a high probability that Alternative 4 would show marked survival and population growth for the Snake River Basin steelhead. In 5 to 10 years, productivity of food-web diversity would increase to the high production of the unimpounded Hells Canyon reach. Coolwater from the Dworshak could negate. Reduction in in-river harvest and increases in habitat related fitness and estuary passage survival could give the same result as the dam breaching alternative. Snake River Basin steelhead require mainstem habitat for overwintering success, which requires active management of near-natural flow shaping, timing, and magnitude in order to keep the habitat maintained.
CUMULATIVE EFFECTS	**CUMULATIVE EFFECTS**	**CUMULATIVE EFFECTS**	**CUMULATIVE EFFECTS**
Corps has deferred its major maintenance and rehabilitation program to a point of critical mass. Ice Harbor needs turbines. Lower Monumental needs a stilling basin. Continuation to defer these maintenance items may be negative to fish. NMFS has determined that future dredging activities would have adverse effects on the salmon and steelhead. Future dredging would also be required thorough the examination of impacts.	Corps has deferred its major maintenance and rehabilitation program to a point of critical mass. Ice Harbor needs turbines. Lower Monumental needs a stilling basin. Continuation to defer these maintenance items may be negative to fish. NMFS has determined that future dredging activities would have adverse effects on the salmon and steelhead. Future dredging would also be required thorough the examination of impacts.	Corps has deferred its major maintenance and rehabilitation program to a point of critical mass. Ice Harbor needs turbines. Lower Monumental needs a stilling basin. Continuation to defer these maintenance items may be negative to fish. NMFS has determined that future dredging activities would have adverse effects on the salmon and steelhead. Future dredging would also be required thorough the examination of impacts.	Dam breaching and adaptive management of coolwater release regimes from Dworshak would result in increased smolt condition and fitness relating to increased survival to the ocean and the return to the Snake River. NMFS CRI shows salmon survival dependent upon production variants such as growth for all lifestages including 1st year growth and fitness to survive hydrosystem, and estuary and near-ocean conditions.
ISSUES	**ISSUES**	**ISSUES**	**ISSUES**
Coolwater releases from Dworshak for flow target and water temperature regulation critically needs re-evaluation for scientific justification of how and when to schedule for best growth and condition of smolts.	Coolwater releases from Dworshak for flow target and water temperature regulation critically needs re-evaluation for scientific justification of how and when to schedule for best growth and condition of smolts. Delayed mortality vectors would be significant. The idea that "current fish transport program is effective at increasing adult returns" is an overgeneralization. The timing and date of release important due to smolt size and fitness and degree of smoltification. All survival and recovery standard transport's metrics performance dependent upon what is distribution of D values and in-river's extra mortality (not zero). Only increased effort in research and monitoring can resolve the uncertainties regarding delayed and extra mortality. There would likely not be enough information to address these issues by the 3-, 5-, or even 8-year evaluation dates established in the 2000 BiOp to facilitate Adaptive Management and Spread-the-Risk Policy.	Coolwater releases from Dworshak for flow target and water temperature regulation critically needs re-evaluation for scientific justification of how and when to schedule for best growth and condition of smolts. Structural manipulation of the hydrosystem has reached its critical mass, no new fixes at affordable prices are left to tweak in prototype research (ISAB, NMFS 2000 BiOp). Relatively high dam passage survivals exist, reservoir survival and post-hydrosystem survival are critical. The subyearlings reaction to an SBC or RSW still needs to be evaluated. Subyearling behavior is for deeper passage, which might suggest that the ESBS might be equal to or even more beneficial than other bypass and collection measures.	The D value does not functionally exist with dam breaching, but extra mortality in model error terms remains. Adaptive (spread-the-risk) Management has run its course as a failed, statistically confusing management scheme. Adaptive Management takes too many years without resulting in identification of significant causal effects. Sediment management would be required for up to 5 years following breach. Alternative 4, "uncertainties" with sediment, can be tested via experimental management by breaching 1 to 2 dams that are not maintained. Rehabilitation construction impacts are long-term actions resulting in critical "adverse effects" to salmonid populations and production. In-water construction activities required for shoreline protection (levees, riprap relocation, etc.) would continue post-breach. Post-breach land ownership and permitted use would be critical to the success for goals and objectives. Active management of restoring habitat components with flow management would have to be emphasized.

Table A-10. Resource Effects Analysis – Aquatic Resources: Pacific Lamprey, River Lamprey, White Sturgeon, Bull Trout, Native Prey Species, Other Native Species

ALTERNATIVES			
1—EXISTING CONDITIONS	**2—MAXIMUM TRANSPORT**	**3—MAJOR SYSTEM IMPROVEMENTS**	**4—DAM BREACHING**
DIRECT AND INDIRECT EFFECTS	**DIRECT AND INDIRECT EFFECTS**	**DIRECT AND INDIRECT EFFECTS**	**DIRECT AND INDIRECT EFFECTS**
Based on lamprey biology, there is a lack of adequate bypass at the dams for juveniles and adults. There are no deep water passages for either life stage. Juveniles tend to use the turbines for passage and have been found impinged on the traveling screens. Juveniles also depend on river flows and currents to transport them downstream. The high voluntary spill may also create some problems for the soft-bodied lamprey.	Based on lamprey biology, there is a lack of adequate bypass at the dams for juveniles and adults. There are no deep water passages for either life stage. Juveniles tend to use the turbines for passage and have been found impinged on the traveling screens. Juveniles also depend on river flows and currents to transport them downstream. Reduced spill volume and TDG production systemwide would benefit lamprey fitness and survival.	Based on lamprey biology, there is a lack of adequate bypass at the dams for juveniles and adults. There are no deep water passages for either life stage. Juveniles tend to use the turbines for passage and have been found impinged on the traveling screens. Juveniles also depend on river flows and currents to transport them downstream. Reduced spill volume and TDG production systemwide would benefit lamprey fitness and survival.	There is a high probability that dam breaching would show high survival and population growth for Pacific lamprey, white sturgeon, and bull trout because the survival has a high dependency on riverine ecology components such as pool-riffle habitat, spring warming trend in water temperature, and unimpeded movements that are currently highly restricted. In 5 to 10 years, productivity of food-web diversity would increase to the high production of the unimpounded Hells Canyon reach. Dworshak coolwater releases could negate.
There are limited amount of critical lamprey spawning and ammocoete production habitats.	There are a limited number of critical lamprey spawning and ammocoete production habitat.	There are a limited number of critical lamprey spawning and ammocoete production habitats.	High sediment loads during breach will be insignificant to fitness or survival of Pacific lamprey, white sturgeon, and bull trout due to their timing of mainstem river use and/or their life history adaptions to survive high volume runoffs in erosive geographical basins. An unknown proportion of lamprey ammocoetes will be impacted with the erosional evacuation of mud and sand for which they reside in during a breach. This mostly likely would not be significant because limited existing data indicates the most suitable and used habitat for this lifestage is located within the Hells Canyon reach.
There are limited data to indicate the degree of passage impacts caused by the dams for bull trout as well as how bull trout use the reservoirs.	There are limited data to indicate the degree of passage impacts caused by the dams for bull trout as well as how bull trout use the reservoirs.	There are limited data to indicate the degree of passage impacts caused by the dams for bull trout as well as how bull trout use the reservoirs.	
Passage for white sturgeon between reservoirs is functionally blocked. This creates confined populations with low reproduction and recruitment in the suitable habitat of Hells Canyon.	Passage for white sturgeon between reservoirs is functionally blocked. This creates confined populations with low reproduction and recruitment in the suitable habitat of Hells Canyon.	Passage for white sturgeon between reservoirs is functionally blocked. This creates confined populations with low reproduction and recruitment in the suitable habitat of Hells Canyon.	
CUMULATIVE EFFECTS	**CUMULATIVE EFFECTS**	**CUMULATIVE EFFECTS**	**CUMULATIVE EFFECTS**
The continued operation of the project would not change the regional status of these aquatic species.	The continued operation of the project would not change the regional status of these aquatic species.	The continued operation of the project would not change the regional status of these aquatic species.	Any delayed mortality vectors or growth/fitness restrictions related to suppressing population growth rates would return to "near-natural" or "normative" influences. The river owners would only be scientifically justified to manage flow/sediment to restore and maintain critical habitat components. Substantial historic information from Snake River residents of the pre-dam period indicates a high probability of a substantial increase (60 to 80 percent) in lamprey spawning and rearing (ammocoete burrow) habitat.

Table A-10. Resource Effects Analysis – Aquatic Resources: Pacific Lamprey, River Lamprey, White Sturgeon, Bull Trout, Native Prey Species, Other Native Species (Continued)

ALTERNATIVES			
1—EXISTING CONDITIONS	**2—MAXIMUM TRANSPORT**	**3—MAJOR SYSTEM IMPROVEMENTS**	**4—DAM BREACHING**
ISSUES	**ISSUES**	**ISSUES**	**ISSUES**
There are no adequate data to justify the extreme degree of lamprey loss since the construction. There is documentation of blockage.	Existing in-river passage conditions should not be allowed to deteriorate to justify higher collection rates for salmonid smolts.	Existing in-river passage conditions should not be allowed to deteriorate to jutify higher collection rates for salmonid smolts.	No current research and monitoring is in place for non-salmon species for which to gage a change from baseline conditions. Life history studies for Pacific lamprey, white sturgeon, and bull trout (and others) strongly indicate that all of these species have evolved and adapted to riverine habitat and flow hydraulics. Adequate data to support the contrary argument that these species have adapted to survive reservoir conditions does not exist and collection of such data would require too many years of research and monitoring without producing any definative results. It is scientifically likely that the only way to keep Pacific lamprey and white sturgeon off the ESA list in the near future would be to return the lower Snake River to riverine conditions with restored geomorphically dynamic critical components. Construction for breach would continue through post-breach, in-water activities required for shoreline protection (levees, riprap relocation, etc), which are long-term cumulative impacts.
There are no adequate data to indicate the degree of passage impacts for bull trout.	There are no adequate data to justify the extreme degree of lamprey loss since the construction. There is documentation of blockage.	There are no adequate data to justify the extreme degree of lamprey loss since the dams construction. There is documentation of blockage.	
All current evaluations and comparisons used for Alternatives 1 though 3 are salmon-centric analytical frameworks that assume actions for salmon would not impact non-salmonid species or system ecology components or functions, such as for Pacific lamprey, river lamprey, white sturgeon, bull trout, and other native species, or how effects on their prey (i.e., crayfish) would influence these population's survival and growth, or any economically driven fisheries established for them (i.e., white sturgeon sportfishery and tribal Pacific lamprey harvest).	There are no adequate data to indicate the degree of passage impacts for bull trout.	There are no adequate data to indicate the degree of passage impacts for bull trout.	
	All current evaluations and comparisons used for Alternatives 1 though 3 are salmon-centric analytical frameworks that assume actions for salmon would not impact non-salmonid species or system ecology components or functions, such as for Pacific lamprey, river lamprey, white sturgeon, bull trout, and other native species, or how effects on their prey (i.e., crayfish) would influence these population's survival and growth, or any economically driven fisheries established for them (i.e., white sturgeon sportfishery and tribal Pacific lamprey harvest).	All current evaluations and comparisons used for Alternatives 1 though 3 are salmon-centric analytical frameworks that assume actions for salmon would not impact non-salmonid species or system ecology components or functions, such as for Pacific lamprey, river lamprey, white sturgeon, bull trout, and other native species, or how effects on their prey (i.e., crayfish) would influence these population's survival and growth, or any economically driven fisheries established for them (i.e., white sturgeon sportfishery and tribal Pacific lamprey harvest).	
Additional structural improvements beyond those proposed would be required in the near future to keep Pacific lamprey, river lamprey, white sturgeon, and a few other native species from being Federally listed under the Endangered Species Act (ESA) in the near future.	Additional structural improvements beyond those proposed would be required in the near future to keep Pacific lamprey, river lamprey, white sturgeon, and a few other native species from being Federally listed under ESA in the near future.	Additional structural improvements beyond those proposed would be required in the near future to keep Pacific lamprey, river lamprey, white sturgeon, and a few other native species from being Federally listed under ESA in the near future.	Post-breach land ownership and permitted use is critical to the success of goals and objectives.

Table A-11. Resource Effects Analysis – Aquatic Resources: Resident Fish

ALTERNATIVES			
1—EXISTING CONDITIONS	**2—MAXIMUM TRANSPORT**	**3—MAJOR SYSTEM IMPROVEMENTS**	**4—DAM BREACHING**
DIRECT AND INDIRECT EFFECTS	**DIRECT AND INDIRECT EFFECTS**	**DIRECT AND INDIRECT EFFECTS**	**DIRECT AND INDIRECT EFFECTS**
Resident fish species composition and abundance would remain the same.	Resident fish species composition and abundance would remain the same.	Resident fish species composition and abundance would remain the same.	Native riverine species are expected increase, while exotic resevoir species are expected to decline.
Recreational fishery would remain the same.	Recreational fishery would remain the same.	Recreational fishery would remain the same.	Predation of juvenile fall chinook would increase, while predation for spring/summer chinook and steelhead would decrease.
Predation of listed species would remain the same.	Predation of listed species would remain the same.	Predation of listed species would remain the same.	
	Reduced spill could result in less gas bubble trauma and more turbine injuries.		Sport fishery would change from warm water reservoir fishery to a steelhead fishery.
			Off-channel mitigation ponds, backwaters, and embayments would drain, thus, leaving fish stranded.
CUMULATIVE EFFECTS	**CUMULATIVE EFFECTS**	**CUMULATIVE EFFECTS**	**CUMULATIVE EFFECTS**
No detectable cumulative effects would be expected.	No detectable cumulative effects would be expected.	No detectable cumulative effects would be expected.	No detectable cumulative effects would be expected.
ISSUES	**ISSUES**	**ISSUES**	**ISSUES**
No significant issues identified.	No significant issues identified.	No significant issues identified.	Short-term lethal effects to resident fish are uncertain.
			Increased angler access would be necessary to develop a new sports fishery.
			For the habitat quality to reach the desired levels, it would require the peak-flow management to accelerate the sediment movement.
			For the habitat restoration to be achieved, it would require the protection of the river corridor.

Table A-12. Resource Effects Analysis – Terrestrial Resources: Vegetation

ALTERNATIVES			
1—EXISTING CONDITIONS	**2—MAXIMUM TRANSPORT**	**3—MAJOR SYSTEM IMPROVEMENTS**	**4—DAM BREACHING**
DIRECT AND INDIRECT EFFECTS	**DIRECT AND INDIRECT EFFECTS**	**DIRECT AND INDIRECT EFFECTS**	**DIRECT AND INDIRECT EFFECTS**
Existing habitat managements (HMUs) (approximately 30,000 acres) would continue to be operated as called for in the management plans. Habitat would continue to mature to the benefit of cavity nesting birds. This would include the 20,000 acres of in-state ownership under the program. Riparian mosaic and wetland emergent communities would continue to be developed as flows were managed for fish passage operations and as tributary sedimentation continued. Grazing restrictions would continue to improve existing dryland habitats and shorelines.	Existing HMUs (approximately 30,000 acres) would continue to be operated as called for in management plans. Habitat would continue to mature to the benefit of cavity nesting birds. This would include the 20,000 acres of in-state ownership under the program. Riparian mosaic and wetland emergent communities would continue to be developed as flows were managed for fish passage operations and as tributary sedimentation continued. Grazing restrictions will continue to improve existing dryland habitats and shorelines.	Existing HMUs (approximately 30,000 acres) would continue to be operated as called for in management plans. Habitat would continue to mature to the benefit of cavity nesting birds. This would include the 20,000 acres of in-state ownership under the program. Riparian mosaic and wetland emergent communities would continue to be developed as flows were managed for fish passage operations and as tributary sedimentation continued. Grazing restrictions will continue to improve existing dryland habitats and shorelines.	There would be large-scale, short-term effects to the existing vegetation communities. There would also be a loss of 2,100 acres of riparian habitat and 669 acres of wetlands. Due to the exposure of approximately 14,000 acres of inundated lands, the long-term gains would be 12,439 acres of upland habitat and 1,482 acres of riparian habitat. The quality of the upland habitat will take a long time (20+ years) to return. Riparian habitat quality would return more quickly and would be a continuum rather than pockets. The invasion of non-native and/or noxious vegetation would demand intensive management to control and/or eradicate in the newly exposed lands. Limiting the cattle and visitor access would become more important to protect critical salmon habitat.
CUMULATIVE EFFECTS	**CUMULATIVE EFFECTS**	**CUMULATIVE EFFECTS**	**CUMULATIVE EFFECTS**
Implementation of the Lower Snake River Fish and Wildlife Compensation Plan continues to work toward fulfilling the requirements of terrestrial habitat mitigation as defined by the Habitat Evaluation Procedure (HEP) and as agreed to between the U.S. Fish and Wildlife Service (USFWS), the Washington Department of Fish and Wildlife (WDFW), and the Corps. The lower Snake River region is unlikely to reach maximization under present operation and management systems in the neat future.	Implementation of the Lower Snake River Fish and Wildlife Compensation Plan continues to work toward fulfilling the requirements of terrestrial habitat mitigation as defined by HEP and as agreed to between the USFWS, the WDFW, and the Corps. The lower Snake River region is unlikely to reach maximization under present operation and management systems in the neat future.	Implementation of the Lower Snake River Fish and Wildlife Compensation Plan continues to work toward fulfilling the requirements of terrestrial habitat mitigation as defined by HEP and as agreed to between the USFWS, the WDFW, and the Corps. The lower Snake River region is unlikely to reach maximization under present operation and management systems in the neat future.	It has taken over 30 years to mitigate approximately 75 percent of the terrestrial habitat lost to implementation of the Lower Snake River Project. It would take at least that long to return the habitat to a similar level of vegetation establishment; however, the quality is expected to improve towards. This is due largely to the transition to a more natural vegetative environment.
ISSUES	**ISSUES**	**ISSUES**	**ISSUES**
The current mitigation program emphasizes the operation and maintenance (O&M) of riparian type habitat in an upland environment at a annual cost of approximately $600,000. Even though the mitigation program is not in-kind, it does provide the region with valuable habitat that continues to improve.	The current mitigation program emphasizes O&M of riparian type habitat in an upland environment at a annual cost of approximately $600,000. Even though the mitigation program is not in-kind, it does provide the region with valuable habitat that continues to improve.	The current mitigation program emphasizes the O&M of riparian type habitat in an upland environment at a annual cost of approximately $600,000. Even though the mitigation program is not in-kind, it does provide the region with valuable habitat that continues to improve.	The establishment of vegetation would be dependent upon the ability of the sediment to recover from a sterile environment void of organic nutrients needed by re-establishment of native plants. It is also important to realize how quickly river processes produce conditions favorable for development of quality habitats. Access control and land ownership would remain an issue to the successful establishment and maintenance of a natural environment upon the newly exposed lands. Intensive efforts to control unwanted vegetation, to stabilize exposed lands such as mudflats/shorelines, and to initiate planting and seeding are critical to positive benefits mentioned above. Will sediment deposited in Lake Wallula increase or decrease shallow-water waterfowl habitat as well as predator habitat? O&M of existing habitats would continue at a higher cost ($600,000) due to irrigation and access difficulty.

Table A-13. Resource Effects Analysis – Terrestrial Resources: Wildlife

ALTERNATIVES			
1—EXISTING CONDITIONS	**2—MAXIMUM TRANSPORT**	**3—MAJOR SYSTEM IMPROVEMENTS**	**4—DAM BREACHING**
DIRECT AND INDIRECT EFFECTS	**DIRECT AND INDIRECT EFFECTS**	**DIRECT AND INDIRECT EFFECTS**	**DIRECT AND INDIRECT EFFECTS**
The diversity of wildlife species, especially song birds, would continue to increase as the vegetation reached various levels of maturity. Species richness would likely be limited due to habitat limitations. Gulls, terns, and cormorants, which feed on fish, would be somewhat restricted along the lower Snake River due to lack of islands providing suitable habitat as in the lower Columbia River.	The diversity of wildlife species, especially song birds, would continue to increase as the vegetation reached various levels of maturity. Species richness would likely be limited due to habitat limitations. Gulls, terns, and cormorants, which feed on fish, would be somewhat restricted along the lower Snake River due to lack of islands providing suitable habitat as in the lower Columbia River.	The diversity of wildlife species, especially song birds, would continue to increase as the vegetation reaches various levels of maturity. Species richness would likely be limited due to habitat limitations. Gulls, terns, and cormorants, which feed on fish, would be somewhat restricted along the lower Snake River due to lack of islands providing suitable habitat as in the lower Columbia River.	Short-term loss of riparian and wetland habitats would have effects on amphibians, reptiles, small mammals, and deer. Increased edge effect along old shoreline would have short-term negative effects on game birds. Loss of open-water habitat would have short-term negative effects on waterfowl. Increased mudflats would have short-term positive effects on shorebirds and colonial-nesting birds. Long-term positive effects would occur for most wildlife groups due to a more contiguous riparian zone and increased upland habitats. Increase in island habitat would benefit waterfowl, however, increase piscivorous fish and bird habitats.
CUMULATIVE EFFECTS	**CUMULATIVE EFFECTS**	**CUMULATIVE EFFECTS**	**CUMULATIVE EFFECTS**
Implementation of the Lower Snake River Fish and Wildlife Compensation Plan would continue to work toward fulfilling the requirements of terrestrial habitat mitigation as defined by HEP and as agreed to between the USFWS, the WDFW, and the Corps. The lower Snake River region would be unlikely to reach maximization under present operation and management systems in the near future.	Implementation of the Lower Snake River Fish and Wildlife Compensation Plan would continue to work toward fulfilling the requirements of terrestrial habitat mitigation as defined by HEP and as agreed to between the USFWS, the WDFW, and the Corps. The lower Snake River region would be unlikely to reach maximization under present operation and management systems in the near future. Increased transportation of salmonids would make fewer fish available for predation through the lower Snake River and lower Columbia River hydrosystem. This would not likely affect predator populations.	Implementation of the Lower Snake River Fish and Wildlife Compensation Plan continues to work toward fulfilling the requirements of terrestrial habitat mitigation as defined by HEP and as agreed to between the USFWS, the WDFW, and the Corps. The lower Snake River region is unlikely to reach maximization under present operation and management systems in the near future. Adaptive migration strategy would make fewer fish available for predation through the lower Snake River and lower Columbia River hydrosystem. This would not likely affect predator populations.	The loss of habitats in the short-term would push highly mobile wildlife species onto adjacent lands, which are largely agricultural/urban. It could also push them onto adjacent waterways, which are fairly saturated at the present time. In some cases these species would create problems for land-owners or public entities managing greenways, parks, or golf courses.
ISSUES	**ISSUES**	**ISSUES**	**ISSUES**
No significant issues identified.	No significant issues identified.	No significant issues identified.	It would be critical to maintain existing HMUs for as long as possible (approximately 20 years) to offset the loss of riparian and wetland. It would be critical to maintain the existing riparian woody vegetation as snags for cavity nesting wildlife.

Table A-14. Resource Effects Analysis – Terrestrial Resources: ESA Plant Species

ALTERNATIVES			
1—EXISTING CONDITIONS	**2—MAXIMUM TRANSPORT**	**3—MAJOR SYSTEM IMPROVEMENTS**	**4—DAM BREACHING**
DIRECT AND INDIRECT EFFECTS	**DIRECT AND INDIRECT EFFECTS**	**DIRECT AND INDIRECT EFFECTS**	**DIRECT AND INDIRECT EFFECTS**
The land area surrounding the current environmental condition would not be dynamic enough to support Endangered Species Act (ESA) plant species such as water and Ute ladies'-tresses. The uplands (shrub-steppe) are protected and could become suitable to ESA species.	The land area surrounding the current environmental condition would not be dynamic enough to support ESA plant species such as water and Ute ladies'-tresses. The uplands (shrub-steppe) are protected and could become suitable to ESA species.	The land area surrounding the current environmental condition would not be dynamic enough to support ESA plant species such as water and Ute ladies'-tresses. The uplands (shrub-steppe) are protected and could become suitable to ESA species.	Exposed lands could potentially provide habitat for Ute ladies'-tresses and water howelli. The uplands (shrub-steppe) are protected and could become suitable to ESA species.
CUMULATIVE EFFECTS	**CUMULATIVE EFFECTS**	**CUMULATIVE EFFECTS**	**CUMULATIVE EFFECTS**
If current or future habitats would support existing ESA plant species, there could be the future opportunities for these species to come off the ESA lists.	If current or future habitats would support existing ESA plant species, there could be future opportunities for these species to come off the ESA lists.	If current or future habitats would support existing ESA plant species, there could be the future opportunities for these species to come off the ESA lists.	If current or future habitats would support existing ESA plant species, there could be the future opportunities for these species to come off the ESA lists.
ISSUES	**ISSUES**	**ISSUES**	**ISSUES**
No significant issues identified.	No significant issues identified.	No significant issues identified.	No significant issues identified.

Table A-15. Resource Effects Analysis – Terrestrial Resources: ESA Wildlife Species

ALTERNATIVES			
1—EXISTING CONDITIONS	**2—MAXIMUM TRANSPORT**	**3—MAJOR SYSTEM IMPROVEMENTS**	**4—DAM BREACHING**
DIRECT AND INDIRECT EFFECTS	**DIRECT AND INDIRECT EFFECTS**	**DIRECT AND INDIRECT EFFECTS**	**DIRECT AND INDIRECT EFFECTS**
The bald eagle would be the only current ESA listed wildlife species found throughout the lower Snake River. The present bald eagle numbers (wintering and potential nesting) are currently higher than in the past. This increase in numbers would be mainly due to the recovery of the species in general. It would also be in-part to the improved habitat after inundation.	The bald eagle would be the only current ESA listed wildlife species found throughout the lower Snake River. The present bald eagle numbers (wintering and potential nesting) are currently higher than in the past. This increase in numbers would be mainly due to the recovery of the species in general. It would also be in-part to the improved habitat after inundation.	The bald eagle would be the only current ESA listed wildlife species found throughout the lower Snake River. The present bald eagle numbers (wintering and potential nesting) are currently higher than in the past. This increase in numbers would be mainly due to the recovery of the species in general. It would also be in-part to the improved habitat after inundation.	Initially the bald eagle use would decline along the lower Snake River due to loss of shoreline vegetation and disruption of the prey base. If lower Snake River vegetation rebounds along with fish runs, eagles should also rebound to their highest numbers ever.
CUMULATIVE EFFECTS	**CUMULATIVE EFFECTS**	**CUMULATIVE EFFECTS**	**CUMULATIVE EFFECTS**
No expected change in overall current trends for recovery of bald eagles.	No expected change in overall current trends for recovery of bald eagles.	No expected change in overall current trends for recovery of bald eagles.	An unlikely change in lower Snake River populations would effect overall status and regional populations of bald eagles.
ISSUES	**ISSUES**	**ISSUES**	**ISSUES**
No significant issues identified.	No significant issues identified.	No significant issues identified.	No significant issues identified.

Table A-16. Resource Effects Analysis – Cultural Resources

ALTERNATIVES			
1—EXISTING CONDITIONS	**2—MAXIMUM TRANSPORT**	**3—MAJOR SYSTEM IMPROVEMENTS**	**4—DAM BREACHING**
DIRECT AND INDIRECT EFFECTS	**DIRECT AND INDIRECT EFFECTS**	**DIRECT AND INDIRECT EFFECTS**	**DIRECT AND INDIRECT EFFECTS**
The reservoir environment could cause erosion or burial of cultural deposits. Natural and man-caused activities may cause erosion of sites along the reservoir's fluctuation zone. Cultural resources below the fluctuation zone within the reservoir would be protected from vandalism.	The reservoir environment could cause erosion or burial of cultural deposits. Natural and man-caused activities may cause erosion of sites along the reservoir's fluctuation zone. Cultural resources below the fluctuation zone within the reservoir would be protected from vandalism.	The reservoir environment could cause erosion or burial of cultural deposits. Natural and man-caused activities may cause erosion of sites along the reservoir's fluctuation zone. Cultural resources below the fluctuation zone within the reservoir would be protected from vandalism.	Cultural resources may become accessible for traditional cultural and scientific purposes. Short-term vandalism may occur until all sites could be protected and/or vegetation re-establishes within the exposed inundation zone. Dam breaching may cause adverse impacts to cultural propereties due movement of sediment loads and/or erosion and cutbank slumping. In addition, agency and public activities could potentially impact the integrity of cultural properties.
CUMULATIVE EFFECTS	**CUMULATIVE EFFECTS**	**CUMULATIVE EFFECTS**	**CUMULATIVE EFFECTS**
Cultural resources may be eroded and/or buried with reservoir sediments that in time could cause adverse impacts.	Cultural resources may be eroded and/or buried with reservoir sediments that in time could cause adverse impacts.	Cultural resources may be eroded and/or buried with reservoir sediments that in time could cause adverse impacts.	Additional sediment may be deposited over cultural resources in Lake Wallula.
ISSUES	**ISSUES**	**ISSUES**	**ISSUES**
The impacts to cultural resources caused by a reservoir environment are evaluated for adverse effects under National Historic Preservation Act (NHPA). The Walla Walla District currently participates in the *Payos Kuus T'cuuKwe* cooperating group, which is addressing many of the impact issues.	The impacts to cultural resources caused by a reservoir environment are evaluated for adverse effects under NHPA. The Walla Walla District currently participates in the *Payos Kuus T'cuuKwe* cooperating group, which is addressing many of the impact issues.	The impacts to cultural resources caused by a reservoir environment are evaluated for adverse effects under NHPA. The Walla Walla District currently participates in the *Payos Kuus T'cuuKwe* cooperating group, which is addressing many of the impact issues.	Federal funding presently supports cultural resource management. Removal of a Federal project could eliminate these Federal cultural resource management funds. A reservoir drawdown may require significant law enforcement and public education prior, during, and following drawdown. Additional engineering design would be needed to determine best way to stabilize reservoir sediment loads covering sites.

Table A-17. Resource Effects Analysis – Native American Indians

ALTERNATIVES			
1—EXISTING CONDITIONS	**2—MAXIMUM TRANSPORT**	**3—MAJOR SYSTEM IMPROVEMENTS**	**4—DAM BREACHING**
DIRECT AND INDIRECT EFFECTS	**DIRECT AND INDIRECT EFFECTS**	**DIRECT AND INDIRECT EFFECTS**	**DIRECT AND INDIRECT EFFECTS**
Continued loss of Pacific lamprey and decreases in fall chinook would be examples of cultural species limited for tribal harvests.	New screening facilities at Little Goose and Lower Granite would help to divert lamprey from the turbines; however, there would continue to be losses to juvenile lamprey out migrating.	New screening facilities at all four lower Snake River facilities would help to divert lamprey from the turbines; however, there would continue to be losses to juvenile lamprey out migrating.	Fall chinook population increases would likely translate into support for the lower Snake River and middle Columbia River harvests. Access to traditional cultural places, ethno-habitats, burial grounds, etc. for tribal and scientific purposes may be available. Pacific lamprey migration may improve in the lower Snake River; however, the lamprey still would have to pass through the lower Columbia River.
CUMULATIVE EFFECTS	**CUMULATIVE EFFECTS**	**CUMULATIVE EFFECTS**	**CUMULATIVE EFFECTS**
As older generations die, knowledge of traditional practices may not be effectively transferred to younger generations.	As older generations die, knowledge of traditional practices may not be effectively transferred to younger generations.	As older generations die, knowledge of traditional practices may not be effectively transferred to younger generations.	Probable improvements for Native American's uses within the Snake River Basin.
ISSUES	**ISSUES**	**ISSUES**	**ISSUES**
In agency operations of lower Snake River facilities, the exercise of treaty rights and Federal responsibilities to consider Native American communities would not be considered to the extent that tribes prefer. Non-salmonid culturally significant fish are targeted for additional consideration for Native American interest and tribal rights. Tradeoffs between drawdown and limits on harvest would create difficult issues for the tribes who have treaty fishing rights. It may also create problems for other groups with fishing interests. Salmon recovery in the northwest would be salmon-centric. A more holistic species approach should be considered, e.g. Pacific lamprey, bull trout, mountain whitefish, and sucker. The Cumulative Risk Initiative (CRI) analysis suggests chinook and steelhead would not increase enough to contribute to tribal harvests.	In agency operations of lower Snake River facilities, the exercise of treaty rights and Federal responsibilities to consider Native American communities would not be considered to the extent that tribes prefer. Non-salmonid culturally significant fish are targeted for additional consideration for Native American interest and tribal rights. Tradeoffs between drawdown and limits on harvest would create difficult issues for the tribes who have treaty fishing rights. It may also create problems for other groups with fishing interests. Salmon recovery in the northwest would be salmon-centric. A more holistic species approach should be considered, e.g. Pacific lamprey, bull trout, mountain whitefish, and sucker. The Cumulative Risk Initiative (CRI) analysis suggests chinook and steelhead would not increase enough to contribute to tribal harvests.	In agency operations of lower Snake River facilities, the exercise of treaty rights and Federal responsibilities to consider Native American communities would not be considered to the extent that tribes prefer. Non-salmonid culturally significant fish are targeted for additional consideration for Native American interest and tribal rights. Tradeoffs between drawdown and limits on harvest would create difficult issues for the tribes who have treaty fishing rights. It may also create problems for other groups with fishing interests. Salmon recovery in the northwest would be salmon-centric. A more holistic species approach should be considered, e.g. Pacific lamprey, bull trout, mountain whitefish, and sucker. The CRI analysis suggests chinook and steelhead would not increase enough to contribute to tribal harvests.	The numbers of returning wild fish is based on 1998 PATH fish return estimates. Some have identified the PATH numbers to be extremely optimistic. The CRI, which looked at probability of extinction, focused on population growth and estimated the best a dam breach would do is improve growth by possibly 10 percent over the 30 to 38 percent estimated for Alternatives 1 through 3. However, it was concluded that even with this percent of improvement, dam breaching would not re-establish fish runs to prevent extinction for certain species. Fall chinook and summer/spring chinook would increase toward recovery. Salmon recovery in the northwest would be salmon-centric. A more holistic species approach would need to be considered, e.g. Pacific lamprey, bull trout, mountain whitefish, and sucker. The CRI analysis suggests chinook and steelhead would not increase enough to contribute to tribal harvests.

Table A-18. Resource Effects Analysis – Social Resources: Community Assessments

ALTERNATIVES			
1—EXISTING CONDITIONS	**2—MAXIMUM TRANSPORT**	**3—MAJOR SYSTEM IMPROVEMENTS**	**4—DAM BREACHING**
DIRECT AND INDIRECT EFFECTS	**DIRECT AND INDIRECT EFFECTS**	**DIRECT AND INDIRECT EFFECTS**	**DIRECT AND INDIRECT EFFECTS**
Downriver sub-region community participants perceived there would be minor beneficial effects due to community growth and improvements, general good quality of life, and increased community cohesiveness. Reservoir sub-region participants perceived there would be minor benefits under this alternative due to an increase in construction related jobs, an increase in industries, an increase in community moral, and an increase in other job-related opportunities. Upriver and southern Idaho sub-region communities had varied responses to the continuation of existing systems but generally no change was mentioned.	The Maximum Transport alternative was not evaluated.	Downriver sub-region community individuals believed this alternative would provide minor benefits due to growth in general, current trends continue and short term jobs. Reservoir sub-region community individuals believed this alternative would provide minor benefits due to increasing school enrollment, population growth, and increasing jobs at dams. Upriver sub-region community individuals perceived that this alternative would provide minor adverse impacts due to increased utility rates, less fish, maintain status quo, and no change. South Idaho sub-region community individuals perceived this alternative would create minor adverse impacts due to perceived decrease in wildlife and fish, loss/change in recreation and tourism opportunities, and loss of jobs.	Downriver sub-region community residents perceived major adverse impacts would occur if drawdown were implemented due to high public assistance, decreasing job opportunities, negative effects of alternative energy production, traffic congestion, and negative impacts on farming communities. Reservoir sub-region community residents perceived major adverse impacts if drawdown implemented due to insufficient/decreasing tax base, negative economic opportunities, traffic congestion, decrease in job opportunities and ripple effect from agricultural losses. Upriver sub-region community individuals perceived drawdown would provide mixed results from minor beneficial impacts to minor adverse impacts. Minor beneficial impacts due to increased population and positive impacts associated with fish recovery. Minor adverse impacts due to perceived unstable economy, increase in utility costs, and increased transportation costs. South Idaho sub-region community individuals perceived drawdown would create mixed results from minor beneficial impacts to minor adverse impacts. Minor beneficial impacts conveyed by residents of Boise and Twin Falls included growth in recreation, strong improved fisheries, and a strong sense of place and heritage. Smaller agricultural communities perceived minor adverse impacts to occur due to decreasing job opportunities, lack of money for community improvements, and increasing transportation costs.
CUMULATIVE EFFECTS	**CUMULATIVE EFFECTS**	**CUMULATIVE EFFECTS**	**CUMULATIVE EFFECTS**
No new cumulative effects. All social effects are typically cumulative in nature.	The Maximum Transport alternative was not evaluated.	No additional effects identified.	All sub-regions would have communities affected by dropping agricultural commodity rates, rising transportation costs, and concerns about rising fuel and power costs. Several reservoir sub-region community members expressed cumulative effects of these factors combined with implementation of drawdown would put them out of business and communities would be lost. Some upstream sub-region communities have survived the decline in the logging industry and adapted to recreation and tourism. A strong fishery is their goal. This goal may be achieved. Communities believe the breaching alternative is their best hope for healthy salmon returns.
ISSUES	**ISSUES**	**ISSUES**	**ISSUES**
All draft conclusions presented to the communities in 1999 about anadromous fish future populations were based on PATH 1998 models. The CRI model data developed in late 1999 may cause some community members to change their perceptions of future impacts to their communities.	The Maximum Transport alternative was not evaluated.	All draft conclusions presented to the communities in 1999 about anadromous fish future populations were based on PATH 1998 models. The CRI model data developed in late 1999 may cause some community members to change their perceptions of future impacts to their communities.	All draft conclusions presented to the communities in 1999 about anadromous fish future populations were based on PATH 1998 models. The CRI model data developed in late 1999 may cause some community members to change their perceptions of future impacts to their communities.

Table A-19. Resource Effects Analysis – Social Resources: Low Income/Minority Populations

ALTERNATIVES			
1—EXISTING CONDITIONS	**2—MAXIMUM TRANSPORT**	**3—MAJOR SYSTEM IMPROVEMENTS**	**4—DAM BREACHING**
DIRECT AND INDIRECT EFFECTS	**DIRECT AND INDIRECT EFFECTS**	**DIRECT AND INDIRECT EFFECTS**	**DIRECT AND INDIRECT EFFECTS**
Dam construction has been a factor in salmon declines; therefore, their continued presence would do little to change the current tribal circumstances.	Dam construction has been a factor in salmon declines; therefore, their continued presence would do little to change the current tribal circumstances.	Dam construction has been a factor in salmon declines; therefore, their continued presence would do little to change the current tribal circumstances.	Increased fish recovery would benefit the tribes. Exposure of inundated lands would benefit the tribes.
Irrigation from Lake Sacajawea supports 13 farms totaling about 37,000 acres. These farms provide jobs for farm laborers.	Irrigation from Lake Sacajawea supports 13 farms totaling about 37,000 acres. These farms provide jobs for farm laborers.	Irrigation from Lake Sacajawea supports 13 farms totaling about 37,000 acres. These farms provide jobs for farm laborers.	Hispanics make up 84 to 90 percent (1,935 to 2,074) of the farm labor workers in Walla Walla and Franklin counties. This minority population would be disproportionately affected if a large percent of these people lost their jobs.
CUMULATIVE EFFECTS	**CUMULATIVE EFFECTS**	**CUMULATIVE EFFECTS**	**CUMULATIVE EFFECTS**
No new changes to cumulative problems associated with low income and minority populations.	No new changes to cumulative problems associated with low income and minority populations.	No new changes to cumulative problems associated with low income and minority populations.	Increased fish recovery benefits would marginally benefit regional tribes as a whole, but losses to jobs would negatively effect Hispanic populations of the region.
ISSUES	**ISSUES**	**ISSUES**	**ISSUES**
The numbers of returning wild fish is based on 1998 PATH fish return estimates. Some have identified the PATH numbers to be extremely optimistic. The CRI, which looked at probability of extinction, focused on population growth and estimated the best a dam breach would do is improve growth by possibly 10 percent over the 38 to 44 percent estimated for Alternatives 1 through 3. However, it was concluded that even with this percent of improvement, dam breaching would not re-establish fish runs to prevent extinction.	The numbers of returning wild fish is based on 1998 PATH fish return estimates. Some have identified the PATH numbers to be extremely optimistic. The CRI, which looked at probability of extinction, focused on population growth and estimated the best a dam breach would do is improve growth by possibly 10 percent over the 38 to 44 percent estimated for Alternatives 1 through 3. However, it was concluded that even with this percent of improvement, dam breaching would not re-establish fish runs to prevent extinction.	The numbers of returning wild fish is based on 1998 PATH fish return estimates. Some have identified the PATH numbers to be extremely optimistic. The CRI, which looked at probability of extinction, focused on population growth and estimated the best a dam breach would do is improve growth by possibly 10 percent over the 38 to 44 percent estimated for Alternatives 1 through 3. However, it was concluded that even with this percent of improvement, dam breaching would not re-establish fish runs to prevent extinction.	The numbers of returning wild fish is based on 1998 PATH fish return estimates. Some have identified the PATH numbers to be extremely optimistic. The CRI, which looked at probability of extinction, focused on population growth and estimated the best a dam breach would do is improve growth by possibly 10 percent over the 38 to 44 percent estimated for Alternatives 1 through 3. However, it was concluded that even with this percent of improvement, dam breaching would not re-establish fish runs to prevent extinction.

Table A-20. Resource Effects Analysis – Land Ownership and Use

ALTERNATIVES			
1—EXISTING CONDITIONS	**2—MAXIMUM TRANSPORT**	**3—MAJOR SYSTEM IMPROVEMENTS**	**4—DAM BREACHING**
DIRECT AND INDIRECT EFFECTS	**DIRECT AND INDIRECT EFFECTS**	**DIRECT AND INDIRECT EFFECTS**	**DIRECT AND INDIRECT EFFECTS**
A large amount of the regional land use would remain agriculture.	A large amount of the regional land use would remain agriculture.	A large amount of the regional land use would remain agriculture.	A large amount of the regional land use would remain agriculture; however, it could go from irrigated to dryland or grazing. Newly exposed lands (approximately 14,000 acres) would be managed for terrestrial mitigation and for habitat critical to anadromous fish. Existing Real Estate outgrants would remain. Additional outgrants would be required to allow recreational facilities the ability to operate. Lake recreational users would be displaced. Loss of water supply would affect income production of agriculture lands. Regional roads would see more truck traffic delivering farm products to the market.
CUMULATIVE EFFECTS	**CUMULATIVE EFFECTS**	**CUMULATIVE EFFECTS**	**CUMULATIVE EFFECTS**
No changes for direct and indirect effects, all of which are cumulative.	No changes for direct and indirect effects, all of which are cumulative.	No changes for direct and indirect effects, all of which are cumulative.	Displacement of lake recreational users could become a problem with the increased use of Dworshak Reservoir waters for fish passage and temperature regulation. Corporate farms continue to contribute to the loss of the family farms. Loss of water supply would affect the income and production of agriculture lands. It would also increase costs for transportation of goods. Market prices for farm commodities are already rock bottom.
ISSUES	**ISSUES**	**ISSUES**	**ISSUES**
No significant issues identified.	No significant issues identified.	No significant issues identified.	No significant issues identified.

Table A-21. Resource Effects Analysis - Aesthetics

ALTERNATIVES			
1—EXISTING CONDITIONS	**2—MAXIMUM TRANSPORT**	**3—MAJOR SYSTEM IMPROVEMENTS**	**4—DAM BREACHING**
DIRECT AND INDIRECT EFFECTS	**DIRECT AND INDIRECT EFFECTS**	**DIRECT AND INDIRECT EFFECTS**	**DIRECT AND INDIRECT EFFECTS**
Physical environment would remain unchanged.	Physical environment would remain unchanged. Dams visitors would observe less spill than what is presently done during the fish passage season.	Physical environment would remain unchanged.	In short-term, there would be an additional 14,000 acres of mud flat with bad smells as things would change. Long-term change would result in a more natural riverine environment with water and vegetation in a natural relationship. Deconstruction activities would result in an increase of noise. A short-term increase in fugitive dust would occur from not only deconstruction, but also from mudflats drying out and sediments dispersed by wind. Loss of barge traffic would require a significant increase in truck and rail traffic not only in the lower Snake River corridor but also on regional highways. Four large abandoned concrete structures along with possible abandoned grain elevators, irrigation structures, and recreational facilities would remain along the 140-mile stretch of the near-natural river.
CUMULATIVE EFFECTS	**CUMULATIVE EFFECTS**	**CUMULATIVE EFFECTS**	**CUMULATIVE EFFECTS**
No cumulative effects identified.	No cumulative effects identified.	No cumulative effects identified.	In the regional sense, dam breaching would be of interest to sight-seeing in the inland areas of the Pacific Northwest.
ISSUES	**ISSUES**	**ISSUES**	**ISSUES**
No significant issues identified.	No significant issues identified.	No significant issues identified.	No significant issues identified.

Table A-22. Resource Effects Analysis – Economics: National Economic Development

ALTERNATIVES

DIRECT AND INDIRECT EFFECTS

	1—EXISTING CONDITIONS	2—MAXIMUM TRANSPORT		3—MAJOR SYSTEM IMPROVEMENTS		4—DAM BREACHING	
	COSTS	NET COSTS	NET BENEFITS	NET COSTS	NET BENEFITS	NET COSTS	NET BENEFITS
Transportation	$182,400,000					-$37,813,000	
Water Supply	Unknown					-$15,424,000	
Implementation Cost	$15,500,000		$3,460,000	-$22,880,000		-$48,790,000	
Commercial Fishing	$2,800,000		$160,000		$158,000		$1,486,000
Avoided Costs	$72,320,000			-$10,000			$33,570,000
Recreation	$51,500,000		$1,405,000		$1,437,000		$71,255,000
Power	$18,200,000,000		$8,500,000		$8,500,000	-$271,000,000	
TOTAL:			**$13,525,000**	**-$22,890,000**	**$10,095,000**	**-$373,027,000**	**$106,311,000**
NET COST:			**$13,525,000**	**-$12,795,000**		**-$266,716,000**	

CUMULATIVE EFFECTS

1—Existing Conditions: All economic effects are cumulative.

2—Maximum Transport: All economic effects are cumulative.

3—Major System Improvements: All economic effects are cumulative.

4—Dam Breaching: Under this alternative, commodities currently transported by barge on the lower Snake River would need to be shipped by rail or truck. Infrastructure improvements would be required to accommodate projected increases in rail and truck traffic. Average annual costs for these improvements are estimated to range from $4.3 million to $27.2 million using a 6.875 percent discount rate.

ISSUES

1—Existing Conditions: No significant issues identified.

2—Maximum Transport: No significant issues identified.

3—Major System Improvements: No significant issues identified.

4—Dam Breaching: Hydropower production and barge transportation would no longer be possible under this alternative.

Serious concerns remain with the recreation estimates developed by the DREW Recreation Workgroup. These concerns, which are summarized in Appendix I, suggest that the estimated recreation benefits associated with Alternative 4–Dam Breaching may be significantly overstated.

Transportation infrastructure improvement costs are not part of the cost associated with Alternative 4–Dam Breaching. However, expenditures on transportation infrastructure would be necessary to accommodate projected increases in rail and truck traffic.

No dollar value above the commercial value of the fish was assigned to Tribal Ceremonial and Subsistence Harvest. Although a tribal perspective on the proposed alternatives is summarized in Appendix I, the absence of a dollar value suggests that from an NED perspective Tribal Harvest is undervalued with respect to the other evaluated resource areas.

Note: Net costs for Alternatives 2 through 4 are average annual costs projected over the 100-year economic study period and discounted using a 6.875 percent discount rate.

Table A-23. Resource Effects Analysis – Economics: Passive Use Values

ALTERNATIVES			
1—EXISTING CONDITIONS	**2—MAXIMUM TRANSPORT**	**3—MAJOR SYSTEM IMPROVEMENTS**	**4—DAM BREACHING**
DIRECT AND INDIRECT EFFECTS	**DIRECT AND INDIRECT EFFECTS**	**DIRECT AND INDIRECT EFFECTS**	**DIRECT AND INDIRECT EFFECTS**
The passive use analysis conducted by the DREW Recreation Workgroup assumed that there are no passive use values associated with the existing lower Snake River dams and reservoirs.	The incremental average annual passive use value for the projected increase in anadromous fish under this alternative is estimated to range from \$0.25 million to \$4.02 million. Although projected increases in anadromous fish were lower under this alternative than under alternative over the 100-year study period, they were larger in the first few decades resulting in a larger discounted average annual cost.	The incremental average annual passive use value for anadromous fish under this alternative is estimated to range from \$0.657 million to \$31.09 million <u>less</u> than Alternative 1. This is because projected increases in anadromous fish wold be lower under this alternative than under Alternative 1.	The incremental average annual passive use value for anadromous fish under this alternative is estimated to range from \$22.77 million to \$301.51 million. Average annual returns of wild fish are projected to be 118,571 under this alternative compared to 71,110 under Alternative 1. This is an increase of 67 percent. In addition, the passive use value of a near-natural lower Snake River was estimated at \$420 million per year.
CUMULATIVE EFFECTS	**CUMULATIVE EFFECTS**	**CUMULATIVE EFFECTS**	**CUMULATIVE EFFECTS**
Passive use values are cumulative in nature.	Passive use values are cumulative in nature.	Passive use values are cumulative in nature.	Passive use values are cumulative in nature.
ISSUES	**ISSUES**	**ISSUES**	**ISSUES**
It could be argued that there are passive use values associated with existing conditions. Individuals may value the continued operation of the dams, even though they may not directly benefit from or use the dams or reservoirs themselves. People may also hold passive use values for a traditional way of life, such as commercial fishing or the family farm.	While the concept of passive use value is rarely challenged, there is considerable controversy surrounding its measurement.	While the concept of passive use value is rarely challenged, there is considerable controversy surrounding its measurement.	While the concept of passive use value is rarely challenged, there is considerable controversy surrounding its measurement. Estimates of the number of wild salmon and steelhead available for harvest were developed by the DREW Anadromous Fish Workgroup based on the findings at the 1998 PATH analysis. Additional analysis has been conducted since completion of the DREW passive use study, resulting in the 1999 PATH results and the CRI analysis. The revised PATH analysis found higher adult return projections under Alternatives 1 and 3, which reduced the net difference between these alternatives and Alternative 4. These adjusted results were supported by the CRI modeling results. Using these revised results would lower the estimated anadromous fish passive use value for Alternative 4, which is calculated net of Alternative 1. The CRI, which looked at the probability of extinction, focused on population growth and estimated that dam breaching would at best improve growth by 10 percent over the 38 to 44 percent improvement estimated for Alternatives 1 through 3. However, it was concluded that even with this percent of improvement, dam breaching would not sufficiently re-establish fish runs to prevent extinction.

ANNEX B

RESOURCE AREA EVALUATION AND UNCERTAINTY ANALYSIS

Table B-1. Resource Area Valuation and Uncertainty Analysis

Resource Areas	Measurement Effects			Effects				Uncertainty			
	Criteria	Scale	Best	Existing Conditions	Maximim Transport	Major System Improvements	Dam Breaching	Existing Conditions	Maximum Transport	Major System Improvements	Dam Breaching
Geology and Soils											
Erosion	Impacts	Hi, Med, Lo	Lo	Lo	Lo	Lo	Hi - Med	Lo	Lo	Lo	Med
Embankment Failures	Impacts	Hi, Med, Lo	Lo	Lo	Lo	Lo	Hi	Lo	Lo	Lo	Med
TSS Contribution	Impacts	Hi, Med, Lo	Lo	Lo	Lo	Lo	Hi - Med	Lo	Lo	Lo	Med
Air Quality											
Fugitive Dust	PM10	% Increase	0	0	0	0	1	Lo	Lo	Lo	Med
Greenhouse Gases	CO2	% Increase	0	0	0	0	1	Lo	Lo	Lo	Lo
Transportation Emissions	Impacts	Hi,Med, Lo	Lo	Lo	Lo	Lo	Lo	Lo	Lo	Lo	Lo
AAQS	Compliance	Yes, No	Yes	Yes	Yes	Yes	Yes	Med	Med	Med	Med
Water Resources											
Temperature [a]	Days Exceedence	Above 20°C	0	50-70	50-70	50-70	55-65	10-20%	10-20%	10-20%	10-20%
Dissolved Gases [a]	Days Exceedence	Above 110%	0	130-170	30-50	30-50	0	70-80%	40-50%	40-50%	10%
Sediments [a]											
Short-term	TSS mg/l	20 - 9000	0	20-1000	20-1000	20-1000	5,000 - 9,000	40-70%	40-70%	40-70%	20-30%
Long-term	TSS mg/l	20 - 1000	0	20-1000	20-1000	20-1000	20-1000	40-70%	40-70%	40-70%	40-70%
Total Volume Transported	MCY Above Annual Load	0-75	0	0	0	0	50-75				10-20%
Contaminants											
DDT	mg/l resuspended	0 - 1.7	0	0	0	0	1.6 - 1.7	None	None	None	50-70%
Ammonia	mg/l resuspended	0 - 5	0	0	0	0	3 - 5	None	None	None	50-70%
Manganese	mg/l resuspended	0 - 1400	0	0	0	0	400 - 1400	None	None	None	50-70%
Zinc	mg/l resuspended	0 - 38	0	0	0	0	14 - 38	None	None	None	50-70%
Aquatic Resources											
Anadromous											
Spring/Summer Chinook											
Population Growth Index	Lambda [b/c]	0.98 - 1.10	> 1.0 [d]	0.98 - 1.01	1.03 - 1.08	1.03 - 1.08	1.04 - 1.10	0.88 - 1.05	0.93 - 1.13	0.93 - 1.13	0.95 - 1.14
System Juvenile Survival (T) [e]	Percent [f]	40.5 to 63.7	100	27 - 52 (50 - 64)	35 - 62 (51 - 65)	35 - 62 (51 - 65)	40.5 - 63.7 (n/a)	Lo	Med	Med	Med
System Adult Survival	Percent	82.5 to 85.5	100	83	86	86	86	75 - 87	78.5 - 90.5	78.5 - 90.5	88.0 - 93.3
Critical Habitat [g]	Percent Change	-35.0 to 0.0	100	P: -35.0 to -15.0	P: -35.0 to -25.0	P: -25.0 to -10.0	P: -10.0 to 0.0	Hi	Hi	Med	Lo
Fall Chinook											
Population Growth Index	Lambda [b/c]	0.87 to 1.05	> 1.0 [d]	0.87 - 0.92	0.93 - 1.03	0.93 - 1.03	0.95 - 1.05	No Additional Data	No Additional Data	No Additional Data	No Additional Data
System Juvenile Survival (T) [e]	Percent [f]	12.7 to 37.0	100	0.5 - 16 (6 - 157)	1 - 22(8 - 16)	1 - 22(8 - 16)	23.0 - 37.0 (n/a)	Med	Med	Med	Med
System Adult Survival	Percent	71 to 74	100	71	74	74	74	60.7 - 81.3	63.7 - 84.3	63.7 - 84.3	77.9 - 90.2
Critical Habitat [g]	Percent Change	-45.0 to 0.0	+100	P: -40.0 to -20.0	P: -45.0 to -25.0	P: -25.0 to -15.0	P: -20.0 to 0.0	Hi	Hi	Med	Med
	Percent Change	-70.0 to -10.0	+100	R: -60.0 to -40.0	R: -70.0 to -50.0	R: -40.0 to -25.0	R: -30.0 to -10.0	Med	Hi	Med	Med
	Percent Change	-95.0 to -10.0	+100	S: > -90.0	S: > -95.0	S: > -90.0	S: > -20.0 to -10.0	Lo	Lo	Lo	Med
Steelhead											
Population Growth Index	Lambda [b/c]	0.74 to 0.94	> 1.0 [d]	0.74 - 0.83	0.77 - 0.90	0.77 - 0.90	.075 - 0.94	No Additional Data	No Additional Data	No Additional Data	No Additional Data
System Juvenile Survival (T) [e]	Percent [f]	41.0 to 65.0	100	32 - 46 (45 - 52)	42 - 58 (46 - 55)	42 - 58 (46 - 55)	41.0 - 65.0 (n/a)	Med	Med	Med	Hi
System Adult Survival	Percent	77.3 to 80.3	100	77.3	80.3	80.3	80.3	73.0 - 79.6	76.0 - 82.6	76.0 - 82.6	88.4 - 92.2
Critical Habitat [g]	Percent Change	-35.0 to 0.0	+100	P: -35.0 to -15.0	P: -35.0 to -25.0	P: -25.0 to -10.0	P: -10.0 to 0.0	Hi	Hi	Med	Lo
	Percent Change	-45 to -5.0	+100	R: -40.0 to -20.0	R: -45.0 to -25.0	R: -25.0 to -15.0	R: -10.0 to -5.0	Hi	Hi	Hi	Med

Table B-1. Resource Area Valuation and Uncertainty Analysis (continued)

Resource Areas	Measurement Effects			Effects				Uncertainty			
	Criteria	**Scale**	**Best**	**Existing Conditions**	**Maximum Transport**	**Major System Improvements**	**Dam Breaching**	**Existing Conditions**	**Maximum Transport**	**Major System Improvements**	**Dam Breaching**
Sockeye	Impacts	Hi, Med, Lo	Lo	Med	Med	Med	Lo	Med	Hi	Med-Hi	Hi
Lamprey	Impacts	Hi, Med, Lo	Lo	Hi	Hi	Med	Lo	Hi	Hi	Med	Lo
Resident											
Native Species	Native Species	Percent	100	79	79	79	86	Lo	Lo	Lo	Lo
Recreational Fishery	Potential	Hi, Med, Lo	Hi	Hi	Hi	Hi	Hi	Lo	Lo	Lo	Lo
Terrestrial Resources											
Habitat											
Wetlands	Acres	294 to 963		963	963	963	294	Lo	Lo	Lo	Lo
Riparian	Acres	1,804 to 3,285		1,804	1,804	1,804	3,285	Lo	Lo	Lo	Lo
Uplands	Acres	18,150 to 30,589		18,150	18,150	18,150	30,589	Lo	Lo	Lo	Lo
Wildlife b/											
Game Birds	Impacts	Hi, Med, Lo	Lo	Med	Med	Med	Hi - Lo	Lo	Lo	Lo	Lo - Med
Waterfowl	Impacts	Hi, Med, Lo	Lo	Med	Med	Med	Hi - Med	Lo	Lo	Lo	Lo - Med
Shore-birds	Impacts	Hi, Med, Lo	Lo	Med	Med	Med	Lo - Med	Lo	Lo	Lo	Lo - Med
Colonial Nesting Birds	Impacts	Hi, Med, Lo	Lo	Hi	Hi	Hi	Med - Hi	Lo	Lo	Lo	Lo - Med
Raptors	Impacts	Hi, Med, Lo	Lo	Med	Med	Med	Med - Lo	Lo	Lo	Lo	Lo - Med
Other Non-game Birds	Impacts	Hi, Med, Lo	Lo	Med	Med	Med	Hi - Lo	Lo	Lo	Lo	Lo - Med
Mammals	Impacts	Hi, Med, Lo	Lo	Med	Med	Med	Hi - Lo	Lo	Lo	Lo	Lo - Med
Amphibians & Reptiles	Impacts	Hi, Med, Lo	Lo	Med	Med	Med	Hi - Lo	Lo	Lo	Lo	Lo - Med
ESA Plant Species	Impacts	Hi, Med, Lo	Lo	Hi	Hi	Hi	Med	Lo	Lo	Lo	Lo
ESA Wildlife Species	Impacts	Hi, Med, Lo	Lo	Med	Med	Med	Lo	Lo	LO	Lo	Lo
Cultural Resources											
Site Access											
Shore Zone/Reservoir Flucuation Area	Accessibility	Yes, No	Yes	Yes	Yes	Yes	Yes				
Inundation Zone	Accessibility	Yes, No	Yes	No	No	No	Yes				
Site Impacts											
Shore Zone	Impacts	Hi, Med, Lo	Lo	Lo	Lo	Lo	Lo				
Reservoir Fluctuation Area	Impacts	Hi, Med, Lo	Lo	Hi	Hi	Hi	Lo				
Inundation Zone	Impacts	Hi, Med, Lo	Lo	Med	Med	Med	Med				
Native American Indians											
Harvest											
Spring/Summer Chinook											
0 Year (Baseline)	Wild Fish Returns	284		284	284	No Estimate	284	Lo	Med	Med	Med
10 Year (Short-Term) 1/	Wild Fish Returns	615 to 696		655 (130.0)	615 (116.5)	No Estimate	696 (145.1)	Lo	Med	Med	Med
50 Year (Long-Term) 1/	Wild Fish Returns	1,183 to 4,471		1,538 (441.5)	1,183 (316.5)	No Estimate	4,471 (1,474.3)	Lo	Med	Med	Med
Fall Chinook											
0 Year (Baseline)	Wild Fish Returns	172		172	172	No Estimate	172	Med	Hi	Hi	Med
10 Year (Short-Term) 1/	Wild Fish Returns	848 to 1,243		848 (393.0)	848 (393.0)	No Estimate	1,243 (622.7)	Med	Hi	Hi	Med
50 Year (Long-Term) 1/	Wild Fish Returns	1,086 to 6,745		1,086 (531.4)	1,086 (531.4)	No Estimate	6,745 (3,821.5)	Med	Hi	Hi	Med

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Table B-1. Resource Area Valuation and Uncertainty Analysis (continued)

Resource Areas	Measurement Effects			Effects				Uncertainty			
	Criteria	**Scale**	**Best**	**Existing Conditions**	**Maximum Transport**	**Major System Improvements**	**Dam Breaching**	**Existing Conditions**	**Maximum Transport**	**Major System Improvements**	**Dam Breaching**
Steelhead											
0 Year (Baseline)	Wild Fish Returns	3,185		3185	3185	No Estimate	3185	Med	Hi	Hi	Hi
10 Year (Short-Term) [l]	Wild Fish Returns	4,253 to 4,795		4,406 (38.3)	4,253 (33.5)	No Estimate	4,795 (50.5)	Med	Hi	Hi	Hi
50 Year (Long-Term) [l]	Wild Fish Returns	5,397 to 11,612		5,899 (85.2)	5,397 (69.5)	No Estimate	11,612 (264.6)	Med	Hi	Hi	Hi
Traditional Places	Accessibility	Hi, Med, Lo	Hi	Med	Med	Med	Hi	Lo	Lo	Lo	Lo
Land Ownership and Use											
Regional Land Use	Impacts	Hi, Med, Lo	Lo	Lo	Lo	Lo	Hi	Lo	Lo	Lo	Lo
Lower Snake River Cooridor											
Terrestrial Surface	Acres	27,261.30 - 41,032.90		27,261.30	27,261.30	27,261.30	41,032.90	Lo	Lo	Lo	Lo
Water Surface	Acres	19,464.00 - 32,656.80		32,656.80	32,656.80	32,656.80	19,464.00	Lo	Lo	Lo	Lo
Cattle Access	Acres	572.01		572.01	572.01	572.01	g/	Lo	Lo	Lo	Lo
Outgranted Lands	Acres	4,268.29		4,268.29	4,268.29	4,268.29	h/	Lo	Lo	Lo	Lo
Social Resources											
Low Income/Minority Populations											
Tribal Members	Impacts	Hi, Med, Lo	Lo	Lo	Lo	Lo	Lo	Lo	Lo	Lo	Lo
Farm Workers	Impacts	Hi, Med, Lo	Lo	Lo	Lo	Lo	Hi	Lo	Lo	Lo	Med
Community Assessments [l]											
Downriver Subregion	Rating	1 to 5 [m/]	5	4	No Estimate	4	1	NA	NA	NA	NA
Reservoir Subregion	Rating	1 to 5 [m/]	5	4	No Estimate	4	1	NA	NA	NA	NA
Upriver Subregion	Rating	1 to 5 [m/]	5	3	No Estimate	2	2 to 4	NA	NA	NA	NA
Southern Idaho Subregion	Rating	1 to 5 [m/]	5	3	No Estimate	2	2 to 4	NA	NA	NA	NA
Aesthetics	Impacts	Hi, Med, Lo	Lo	Lo	Lo	Lo	Hi - Med	Lo	Lo	Lo	Med
Economics											
National Economic Development (NED)											
Implementation	Minimize Cost Increase	12.10 to 64.30 M	12.1	15.50	12.10	38.40	64.30	14.75 - 16.31	11.47 - 12.67	36.49 - 4033	61.1 - 67.54
Power	Minimize Cost Increase	18,191.50 to 18,471 M	18,191.50	18,200.00	18,191.50	18,191.50	18,471.00	NA	NA	NA	18,451 - 18,491
Transportation	Minimize Cost Increase	182.40 to 220.20 M	182.4	182.40	182.40	182.40	220.20	NA	NA	NA	210.16 - 230.03
Recreation	Maximize Benefit	51.50 to 121.70 M	121.7	51.50	52.80	52.80	121.70	40.76 - 85.455	41.715 - 87.469	41.75 - 87.542	62.539 - 372.683
Water Supply	Minimize Cost Increase	0 to 15.40 M	0	0.00	0.00	0.00	15.40	NA	NA	NA	13.9 - 16.9
Avoided Cost	Minimize Cost Increase	38.75 to 72.32 M	38.75	72.32	72.32	72.32	38.75	68.70 - 75.94	68.70 - 75.94	68.70 - 75.94	31.23 - 34.51
Commercial Harvest	Maximize Benefit	2.80 to 5.01 M	5.01	2.80	3.14	3.13	5.01	1.2 -7.8	1.3 - 8.0	1.3 - 8.0	2.2 - 10.6

Table B-1. Resource Area Valuation and Uncertainty Analysis (continued)

Resource Areas	Measurement Effects			Effects				Uncertainty			
	Criteria	Scale	Best	Existing Conditions	Maximum Transport	Major System Improvements	Dam Breaching	Existing Conditions	Maximum Transport	Major System Improvements	Dam Breaching
Passive Use											
Wild Salmon & Steelhead	Willingness to Pay	31.1 - 301.6	-	Not Analysed	4.0	-31.1	49	NA	NA	NA	22.8 - 301.6
Free Flowing River	Willingness to Pay	0 -420	-	NA	NA	NA	420	NA	NA	NA	Not Analyzed

a/ Uncertainty percents indicate mean yearly variation within ranges.

b/ Lambda numbers are based on average lambda of the index stocks as reported in Table 9.7-6, NMFS 2000 Biological Opinion. The low number represents assumption that hatchery origin natural spawners have been 80% effective as wild spawners historically. The high number represents assumption that hatchery-origin natural spawners have been 20% as effective as wild spawners historically, except for the Imnaha (50% as effective). For index stocks, it also includes preliminary 2000 and projected 2001 returns in time series used to estimate lambda.

c/ The range reflects lowest and highest lambda of the index stocks. Uncertainties in lambda do not include uncertainties in D. The uncertainty is based on empirical PIT-tag evaluations for Alternatives 1-3, but based on survival per kilometer estimates for Alternative 4.

d/ A lambda >1.0 indicates an increasing population growth index; a lambda <1.0 indicates a declining population growth index.

e/ The number outside the parentheses represents percent system juvenile survival without transportation; the number in the parentheses represents percent system juveneile survival with transportation. Ranges come from Table 9.7-5 in NMFS 2000 Biological Opinion.

f/ First Number is in-river average, parentheses are total system with low and high D. However, for dam breaching there is no D and there is a range for in-river survival. Table 9.7-1 in NMFS 2000 Biological Opinion

g/ Percent critical habitat is described in terms of passage (P), rearing ®, and spawning (S). The numbers represent a change from pre-dam conditions. The numbers can range from a percent loss (-) in habitat to a percent gain (+) in habitat. Pre-dam condition is represented by 0.0.

h/ Under dam breaching the two values reflect first the short-term effect and second the long-term effect.

i/ The number of wild fish expected for harvest by the tribes is reported as a number of wild fish return per year with the percent relative change from 0 Year (Baseline) identifed in parentheses.

j/ The plan is to eliminate cattle watering rights across Government lands, by placing a water system off Corps lands. This would eliminate the acreages to this type of outgrant to zero or near zero.

k/ Outgrants for access to water for recreation purposes will likely increase, however, this cannot be determined until implementation occurs.

l/ Because of the nature of the study methodology, the uncertainties associated with public opinion was not captured.

m/ 1 = Change will produce a Major Adverse Affect
2 = Change will produce a Minor Adverse Affect
3 = No Change
4 = Change will produce a Minor Beneficial Effect
5 = Change will produce a Major Beneficial Effect

Lo-Immeasurable to Slightly Measurable Impacts.

Med-Likely Measurable Impacts

Hi-Very Likely Measureable Impacts

For More Information

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